SECURITY CLASSIFICATION OF THIS PAGE

OCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

AD-A209 660

1b. RESTRICTIVE MARKINGS

3. DISTRIBUTION/AVAILABILITY OF REPORT
Approved for public release;
Distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
7-89

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
US Army-Baylor University
Graduate Program in Health Care

6b. OFFICE SYMBOL (If applicable)
Admin/HSHA-IHC

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
Ft. Sam Houston, TX 78234-6100

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING/SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
A STUDY TO DEVELOP A METHODOLOGY TO DETERMINE MANPOWER REQUIREMENTS FOR THE MATERIEL DISTRIBUTION SERVICE AT THE COLONEL FLORENCE A. BLANCHFIELD ARMY COMMUNITY HOSPITAL

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Study	FROM Jul 84 TO Jul 85	Jun 85	141

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Health Care, Manpower Management; (KT)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This study was conducted to develop a methodology for determining manpower requirements based on workload factors. Actual time for task accomplishment and actual daily workload performed for customer service, stock accounting, and cost accounting sections of the Materiel Distribution Service were recorded. Two manpower prediction formulas, one based on time for task accomplishment and the other on workload accomplished, were derived from the data. A significant difference was found between the predicted manpower requirements. The author concluded the formula based on workload was a better predictive tool due to its inclusion of the minor tasks accomplished that were not measured by the task accomplishment model. Keywords: Manpower utilization;

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[X] UNCLASSIFIED/UNLIMITED [ ] SAME AS RPT. [ ] DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL
Lawrence M. Leahy, MAJ, MS

22b. TELEPHONE (Include Area Code)
(512) 221-6345/2324

22c. OFFICE SYMBOL
HSHA-IHC

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

A STUDY TO DEVELOP

A METHODOLOGY TO DETERMINE MANPOWER REQUIREMENTS FOR THE MATERIEL DISTRIBUTION SERVICE AT THE COLONEL FLORENCE A. BLANCHFIELD ARMY COMMUNITY HOSPITAL

A Graduate Research Project

Submitted to the Faculty of

Baylor University

in Partial Fulfillment of the

Requirements for the Degree

of

Master of Health Administration

by

Major Duane L. Jackson, MSC

June 1985

ACKNOWLEDGEMENTS

This project could not have been accomplished without the help, advice and untiring assistance of many people. First, I wish to thank my preceptor, Colonel Gerald C. Oliver, Deputy Commander for Administration at the Colonel Florence A. Blanchfield Army Community Hospital, Fort Campbell, Kentucky. His leadership, guidance and support were invaluable throughout this project.

The cooperation of all the personnel working in the Materiel Distribution Service greatly enhanced the collection of data and is deeply appreciated. Through observing their daily routines, I was not only able to collect data for this project, but also learn the practical side of operating an MDS function.

I also have to acknowledge the young lady who had the arduous task of typing this report and her untiring efforts to complete the project on a timely basis. More importantly, though, is Mrs. Donna Sanchez's friendly and energetic nature, enduring the many changes that occurred while typing this project, always looking on the bright side of things.

Finally, I cannot overlook my wife and two sons who have endured so much while I was obtaining my education. Many times my wife had to play the dual role of "father" and mother while I was working on various projects. Their unceasing support at home has made this project possible.

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CHAPTER I

INTRODUCTION

Background

A valid concern of logisticians is how to get materiels to the correct user in the right quantity and at the right time.[1] The accomplishment of this goal not only leads to operational efficiency but also helps to reduce costs by minimizing the amount of stock on hand, thereby reducing the potential for pilferage and limiting waste. To help resolve this dilemma, the identification of internal inventory transfer operations as an operating area has been recognized by logisticians to integrate the physical distribution and materiels management operations within an enterprise.[2]

In a hospital environment the internal inventory transfer dilemma translates into a problem of moving supplies from a warehouse or central storage facility to the various wards and clinics in the proper quantity to insure medical support is not interrupted by a stockout condition. To counter this problem, many hospitals have integrated internal inventory transfer operations into the logistical functions through the use of a materiels distribution service - MDS (also commonly called a supply point distribution center - SPD). Distribution of materiel to the wards or clinics from this central storeroom is

generally accomplished by one of three methods: (1) the "fetch-and-carry system"; (2) the Par-level stockage system; or (3) the cart-exchange system.[3] The processes of these three systems are illustrated in Appendix A.

In the fetch-and-carry system, the customer plays an active role in ordering supplies. Someone on the using unit is delegated the responsibility of maintaining adequate levels of supplies, filling out appropriate requisition forms and submitting the request to the central storeroom. The central storeroom fills the request and delivers the materiel to the user. Frequency of this process is dependent upon the actions by the user, while the central storeroom plays a passive role until activated by a supply request.

Par level stockage is based on establishing user stockage levels for each respective area. Individuals from the MDS service go to the user's area at scheduled intervals to physically inventory supplies remaining on the shelf. Upon return to the central storeroom, the quantity inventoried for each item is compared to a pre-established stockage level and replenishment quantities computed. Each commodity on the shelf is then brought back up to the established "par" level by MDS personnel selecting the replenishment stock, returning to the area and placing it on the shelf. The customer is then charged for the materiel issued to bring shelf levels back up to pre-determined levels.[4]

The cart exchange system is based on exchanging entire supply carts in a functional area with identical units that

have been replenished with supplies up to pre-determined levels. Carts that have been removed from the areas are then returned to a central processing point. Each item of supply on a cart is inventoried with the quantity counted compared to a master list containing stockage levels for that specific cart to determine re-stockage quantities. These supplies are then pulled from stock and placed on the cart. Replenished carts are stored and become the replacement carts for the ward or clinic carts at the next scheduled exchange cycle. The functional area is then charged for the supplies necessary to replenish stockage in order to bring each item of supply up to the pre-established level.[5]

Kowalski provides an excellent comparative summary of the three distribution alternatives. Table 1 provides an overview of the summary.

TABLE 1

SUMMARY OF COMPARISONS OF DISTRIBUTION ALTERNATIVES

	FETCH AND CARRY	PAR LEVEL STOCKAGE	CART EXCHANGE
INVENTORY REDUCTION POTENTIAL	LOW	HIGH	HIGH
LABOR UTILIZATION	POOR	FAIR	EXCELLENT
CAPITAL EXPENSE	LOW	LOW	HIGH
SPACE UTILIZATION	POOR	LOW	HIGH
MANAGEMENT CONTROL	POOR	VERY GOOD	EXCELLENT

SOURCE: Jamie C. Kowalski, "Supply Distribution Options - A New Perspective," Hospital Materiel Management Quarterly 2 (November 1980): 86.

United States Army hospitals are currently using all three approaches; however, the par exchange and cart exchange concepts are becoming more popular for the obvious advantages they offer. Of 38 medical treatment facilities within the US Army Health Services Command, 17 employ the cart exchange system, the par level system or a combination of both. The remaining facilities rely upon the customer to order supplies with no automatic replenishment cycle on the part of a central supply source.[6] Of the ten hospitals and medical centers within the Seventh US Army Medical Command in Europe, three are currently utilizing distribution systems composed of either cart exchange or par level processes, or a combination of both. Two other facilities are in the process of implementing such a concept.[7]

Conditions Prompting the Study

In November 1982, movement into the newly constructed Colonel Florence A. Blanchfield Army Community Hospital was accomplished. This facility had replaced an aging cantonment facility built in 1942, consisting of a maze of buildings interconnected by a myriad of corridors occupying 52 acres of land. The new structure consisted of four separate, interconnected buildings with staggered elevations: (1) a five-story administration and inpatient tower; (2) a therapeutic and diagnostic procedures complex; (3) a two-story outpatient building; and (4) a mechanical building (Appendix B).

Two factors lended credibility to the concept of establishing a materiel distribution service and implementing a supply cart system. First, the new structure did not have an abundance of storage room in the functional areas, and second, the physical layout of the facility was deemed to be conducive to such a program.

It was anticipated that the build-up of manpower requirements to staff the materiel distribution service would be partially offset by a reduction in ward and clinic personnel by relieving these units of the responsibility of inventorying, ordering and stocking shelves with supplies. In addition, cost savings were expected through a one-time reduction in inventory in the functional areas as well as continued cost savings by breaking down materiel into the smallest issue unit possible thus limiting stockage to only that amount required on a historical basis for a one to two day supply stockage. These savings had, in fact, been reported by other hospitals converting to a supply cart system. For example, during the first six months of operations, four hospitals of the Catholic Medical Center of Brooklyn and Queens (New York) realized an $800,000 reduction of inventory.[8]

Appropriate Army staffing guides were reviewed to determine the manpower requirements prior to establlishing the Materiel Distribution Service (MDS). When the staffing guide could not provide any guidance, several uniformed treatment facilities using the cart concept were contacted to obtain guidance. Initial staffing of the MDS was based on the advice

and recommendations of other facilities and the experience that had been gained by starting a small pilot program in the old facility prior to movement into the new hospital.

In November 1983, a manpower survey was conducted at Blanchfield Army Community Hospital. Since the staffing guide did not provide an adequate method in which to determine manpower requirements, local appraisal had to be used. With the popularity of using supply carts at Army facilities using both the exchange and par level concepts, it became evident that information regarding staffing of MDS elements was necessary.

The lack of ability to gauge MDS manpower requirements was of local command interest. It was recommended by the Deputy Commander for Administration that a study be performed. When the US Army Health Services Command was contacted to determine what efforts had been previously documented, it was indicated that there were no ongoing studies nor had any studies been performed in the past to substantiate how the MDS should be staffed to the best of their knowledge.[9] Current staffing guidance relied solely on local appraisal, and any information or insight regarding this subject could prove to be beneficial to the team in future surveys.

A literature search found that a study of this problem had not been reported in any hospital, hospital purchasing, or materiels management journal, book, or pamphlet. While the literature was replete with materiel explaining the concepts of par level and cart exchange systems, how to implement them,

associated cost savings, and a multitude of success stories, there was not mention of staff sizing nor guidelines. Conversations with other government operated and civilian hospitals using the cart supply systems indicated a lack of any formal staffing studies and a wide range of staffing variances. A comparison of data between Blanchfield Army Community Hospital and two other institutions using the cart supply system will demonstrate the variances.

Blanchfield Army Community Hospital is a 241-bed facility with 17 outpatient facilities. The MDS currently stocks approximately 1,700 lines, and on a daily basis, exchanges 71 carts and replenishes 22 static (par level) carts. There are a total of 16 full-time equivalents, excluding the MDS supervisor: 11 warehousemen, 3 stock record clerks, and 1 accounting clerk. The MDS at this facility operates around the clock, never ceasing its operations throughout the year. Presently, all functions are performed on a manual basis without any automation support.

The Veterans Administration Medical Center in Nashville, Tennessee, is a 492-bed facility with a wide range of outpatient services. Although larger than Blanchfield Army Community Hospital in terms of inpatient capacity and outpatient visits, the philosophy of supply replenishment and charging issues to a ward or department versus to each patient parallel each other. The VA Medical Center does not use the supply carts concept but does employ the par level replenishment system in 69 storeroom areas. Approximately 800

lines are stocked in the Supply Processing and Distribution (SPD) area. To accomplish this task, there are 11 full-time equivalents excluding himself as supervisor. Ten personnel work in the warehouse area and one works in the ordering and accounting function. Currently, the SPD is operating 14 hours daily, Monday through Friday and is closed on holidays.[10]

Vanderbilt University Hospital is a large teaching facility that has a materiel distribution service stocking approximately 1,500 lines to support a 671-bed facility as well as numerous outpatient clinics. As opposed to the government institutions, costing of supplies is accomplished down to the patient and direct purchasing of supplies from vendors is accomplished by this service. There are 43 full-time equivalents working in the materiel distribution service. Subtracting out personnel that are solely involved with purchasing and costing supplies down to the customer, to gain an equivalency factor, there are 25 FTEs in the warehouse area, 4 personnel in inventory control, and 2 accounting clerks for a total of 31 people. A great deal of automation is used to support the inventory control and accounting functions. Operating 24 hours a day throughout the year, approximately 100 carts are exchanged with 30 par level carts restocked daily.[11]

As seen from these three examples, the number of full-time equivalents can vary by institution. Interviews with materiels managers during the residency in both military government and civilian medical facilities, indicated a lack of any criteria

or method for staffing of the cart supply function. This problem becomes more pronounced when it becomes apparent that all new construction projects for Army hospitals are built with the intent of implementing cart systems[12]. A study into this problem is certainly warranted in light of the lack of knowledge that currently exists. In particular, a pilot study at BACH could possibly serve as a base from which further study can be undertaken to arrive at a universal solution.

Statement of the Research Effort

To develop a methodology for determining manpower requirements for the Materiel Distribution Service at Blanchfield Army Community Hospital, Fort Campbell, Kentucky, based on workload factors.

Objectives

The objectives of this research are to:

1. Identify the major function performed by the MDS at Blanchfield Army Community Hospital.
2. Break down the major function into subtasks adequate for time measurement studies and analysis.
3. Determine the mean time necessary to perform each of the major functions based on the time measurement studies for the subtasks.
4. Determine regression coefficients utilizing average times from objective 3 and standard full-time manpower equivalents. (engineered model)
5. Collect workload and manpower data for the major MDS functions identified over a 90-day time period.

6. From the collected workload data, derive a multiple regression equation to be used to determine manpower needs. (multiple regression model)
7. Calculate the manpower staffing required to operate the MDS by applying the average workload data over the 90-day period to the two equations developed in objectives 4 and 6.
8. Compare the staffing requirements as predicted by the two equations.

Criteria

1. An interval within 1/4 standard deviation of the true value of the mean will be used to determine the sample sizes of the various studies to be performed.
2. A confidence coefficient of .95 will be used when estimating sample sizes required for this study.
3. A level of significance of $\alpha = .05$ will be utilized for all statistical tests performed on the regression analysis model derived by this study.
4. A coefficient of determination, R^2, greater than .8 will be considered significant.
5. A difference in projected manpower requirements greater than ten percent between the two equations when workload data collected during the study is applied will be considered significant.

Assumptions

1. The sample size of performance times collected for the study is representative of the population.

2. The time required to perform the functions to be analyzed bytime measurement study are normally distributed.
3. The "hawthorne" effect will not adversely affect the results of the time measurement studies.

Limitations

1. This study will be based on the materiel distribution service of a medium-sized Army Medical Department Activity (MEDDAC) functioning without direct automated or data processing support.
2. Data will be collected over a 90-day period of time.
3. The physical plant of Blanchfield Army Community Hospital is more of a vertical than horizontal structure thereby affecting distances that have to be traversed to exchange carts.

Literature Review

Little information can be found in the literature regarding the staffing of a materiel distribution service. Part of this dilemma is caused by variations in the design of the hospitals, as well as the local policies of the institution. Because the physical plant can vary by institution; the distances travelled (both horizontal and vertical); the accessibility to elevators to transport the carts; the number of hours the service is open during the week; and the particular services performed by the central materiel service department all impact on how the carts are distributed and on the size of the work force.[13]

In the examples mentioned earlier, Vanderbilt University Hospital and the Veterans Medical Center, both located adjacent to one another in Nashville, Tennessee, have varied manpower requirements. In the case of both institutions, the appropriate manpower required is intuitively derived by the supervisor observing the operations and looking for bottlenecks. When these cannot be resolved by adjusting personnel within the department, an increase in personnel is then considered as an alternative. Vanderbilt University Hospital has an additional requirement in that any increase in personnel must be fully documented with anticipated cost savings generated by the hiring action. The supervisor of the MDS indicated that such cost savings have been challenging to document.[14]

El Camino Hospital, Mountain View, California, performed a study on converting from a fetch and carry system to the exchange cart concept. This study involved the placement of three departments (preoperative, surgical, and postoperative) on an automatic cart replenishment cycle. A labor savings of 23.08 hours for each four-week accounting period was reported when comparing the two systems.[15] However, there was no mention in the article of the number of people involved in the MDS, nor how staffing size was determined.

The majority of literature that can be found regarding the establishment of either a cart exchange or par level replenishment systems center on the attributes of the system from a financial or efficiency perspective. Also, plenty of

information is provided on how to establish such systems, pitfalls to avoid, and suggestions for assuring acceptance within the institution. The researcher has not been able to find any information that provides recommended staffing levels or how to determine staffing requirements.

Research Methodology

The major functions performed by the MDS at Blanchfield Army Community Hospital are broken down into three broad categories: (1) warehouse/customer service, (2) stock accounting, and (3) cost accounting. For each category, the major functions performed on a routine basis were identified for analysis purposes. Appendix C provides a detailed list of the major functions that were identified for each of the job categories. Data collection consisted of two parts: (1) measurement of performance times and (2) the actual daily workload performed for each of the identified functions over a period of time.

Performance times were collected by actual observation, recording the time required to perform the subroutines of each major task. These times were collected on standard time collection sheets prepared for each function (Appendix D). Data collection did not center on any select individual within an MDS job category, rather, the collection of times was a cross section representation of all personnel performing the job function within that area.

After all time measurement data had been collected, an average performance time for each function was calculated. The

computed average performance time was adjusted by dividing the figure by the number of minutes available in a standard manday of work. To obtain an interval within 1/4 standard deviation of the true value of the mean performance time, 62 time-measured observations were made for each function. Appendix E provides the statistical derivation of the sample size.

The standard manday was defined by using an existing Department of the Army standard. Currently, for manpower purposes, the number of personnel available for work in a section is multiplied by a factor of 1.11 to adjust for variables such as vacation time and sick leave. From the total number of manhours available in each year - 2,080 (52 weeks times 40 hours per week) - 72 hours are subtracted due to official holidays (currently 9 per year) leaving a total of 2,008 remaining hours. To arrive at the total number of standard hours available for work, the 2,008 remaining hours was be divided by 1.11. When this factor is applied, the number of standard hours available in a year is 1,809. Dividing the 1,809 by the total number of hours available in a year (2,080), a factor of .8697 is the result. The .8697 represents the productive mean time available per man hour. Applying this factor against a standard eight hour workday, on the average, an individual is available for productive work 6.958 hours; or, in terms of minutes, 417.5 minutes in a workday are available for productive work. This final figure of 417.5 minutes was used in the study as the mean number of

productive minutes available per manday.

Dividing the average time to accomplish each major function by the number of minutes in an average manday provided data as to the number of fractional mandays required each time a major function is performed throughout the day. These derived fractional values were then used as the coefficients (B) of a multiple regression equation expressed as:

$$Y = B_1X_1 + B_2X_2 + B_3X_3 + ... B_nX_n$$

where Y is the number of full time equivalents required to perform the work in a specific category of work within the MDS and X is the number of times a major function is performed in a day. It should be noted that this equation will not have a constant value ("A") as would most multiple regression equations. This is due to the methodology employed in that only those major functions evaluated will be included in the derivation of the equation.

As the second part of the study, average daily workload for the subroutines performed were collected over a 90-day period of time. The number of productive manhours worked by personnel in MDS was determined by the manhours worked as reported on the payroll time cards for civilians and by work time collected by the supervisor for military personnel. After this data was collected, a multiple regression equation will be calculated that best explained the amount of manpower required to perform all the MDS functions on a daily basis.

The time period to be used for the study was 1 October

through 29 December 1984. Although this is traditionally the slowest quarter for workload at Blanchfield Army Community Hospital, the actual work performed as measured by Medical Care Composite Units (MCCUs) is the closest proximate to the MCCU level at which the hospital is currently staffed. Based on the most recent manpower survey, this hospital had recognized requirements for 1,052 personnel; however, the number of authorizations against which personnel could be assigned was set by the United States Army Health Services Command at 81 percent of the recognized level (Appendix F). At full staffing, the hospital was expected to produce 912 average daily MCCUs. Given the authorized level of staffing, this equates in a straight line percentage to 739 average daily MCCUs. During fiscal year 1984, the hospital consistently produced MCCUs well above the authorized manpower staffing level. This trend continued during the first 7 months of fiscal year 1985 (Appendix G). For this reason, a conservative approach was taken and data from what is traditionally the slowest quarter of the fiscal year was used.

After all data was collected, a comparison between the derived multiple regression equation obtained from the time measurement studies and the equation calculated from the workload reports was accomplished to determine any differences. The workload data for the 90-day collection period was then applied to the two regression equations and averaged on a monthly basis to project manpower requirements. Variances of projected manpower requirements between the two

equations was analyzed to determine whether any significant differences were evident.

ENDNOTES

[1]Charles E. Housley, "Distributing the Goods the Right Way," Materiels Management 51 (16 June 1977): pp. 103-105.

[2]Donald J. Bowersox, Logistical Management: A Systems Integration of Physical Distribution Management and Materiels Management, 2nd ed (New York: MacMilland Publishing Co., 1978): p. 70.

[3]Arnold Reisman, Materiels Management for Health Services (Lexington, Mass., D.C. Heath and Co., 1981): p. 37.

[4]Eugene Sandelback, "Cost Containment Through Better Materiels Management," Hospital Financial Management 34 (September 1980): p. 69.

[5]Richard D. Schrock, "Cart Exchange System Aids Financial Control," Hospital Financial Management 31 (May 1977): p. 50.

[6]Interview with Captain Michael D. Daley, Staff Officer, Supply Management Division, Headquarters, US Army Health Services Command, Fort Sam Houston, Texas, 24 May 1985.

[7]Interview with Lieutenant Colonel Spurgeon A. McAdams, Chief, Supply Operations, US Army Seventh Medical Command, Heidelberg, Germany, 31 May 1985.

[8]Lee H. North, "Centralization Helps Catholic Medical Center Contain Costs," Hospital Purchasing News 8 (April 1984): p. 50.

[9]Interview with Mr. Vincent Mack, Chief Manpower Survey Section, Force Development Division, US Army Health Services Command, Fort Sam Houston, Texas, 2 June 1985.

[10]Interview with Mr. Olen Mezick, Director, Supply Processing and Distribution, Veterans Administration Medical Center, Nashville, Tennessee, 23 April 1985.

[11]Interview with Ms. Joan Chandler, Director, Materiel Distribution, Vanderbilt University Hospital, Vanderbilt University, Nashville, Tennessee, 30 April 1985.

[12]Interview with LTC Dale Workman, Chief, Supply Management Branch, US Army Health Services Command, Fort Sam Houston, Texas, 20 June 1985.

[13]Jamie C. Kowalski, "Comprehensive Materials Management," Hospital Progress 58 (March 1977): p. 80.

[14]Chandler, 30 April 1985.

[15]Bruce L. Tilley, "Cart Exchange System Favored for Supply Distribution," Hospitals 55 (March 16, 1981): p. 111.

CHAPTER II

DISCUSSION

General

The determination of how many full time equivalents are required to staff a functional element has always been of concern to managers. In economic terms, it is desirable that the marginal revenue generated by the hiring of an additional person would be equal to or greater than the marginal cost of hiring the additional manpower. As an element of expense for a business, it is hopeful that the salary paid to any additional person would be offset by either an increase in revenues or a corresponding decrease in overall costs due to efficiency factors. Although this sounds simple in theory, the practicality of measuring marginal revenues and marginal expenses can be difficult. This becomes extremely difficult if not impossible in institutions where personnel are not directly involved in revenue generation as is the case in the supply function of a hospital.

As discovered during conversations with managers and administrators at civilian and other federal health care facilities, whether to hire and when to hire additional personnel is a difficult choice to make. In most cases it reverts to trying to determine the minimal number of people required to accomplish the tasks, i.e. minimize cost. At the Veterans Administration Medical Centers, a formal manpower

review process based on workload parameters and appraisal by manpower personnel is required prior to augmenting a section with additional personnel resources. Vanderbilt University Hospital requires a projected cost-benefit analysis. The cost-benefit can either be measured in terms of direct cost savings or as a cost avoidance. The Director of Material Distribution at Vanderbilt Hospital indicated that this can be extremely difficult to determine since some of the costs tend to be more qualitative than quantitative in nature.[1]

The Army has had a formal manpower staffing system in effect for some time. Staffing guides are used for approximations of manpower based on selected measurement factors or "yardsticks" and the volume of work performed. These yardsticks are general in nature and do not necessarily measure all the work a section is required to perform due to local policy variances. The Department of the Army has recognized these shortcomings and recently instituted a Manpower Staffing Standards System as outlined in Army Regulation 570-5 dated 15 April 1984. Based on recent developments in the budgetary process and the emphasis on cost containment by limiting personnel costs, it has become more imperative that personnel resources be justified. Furthermore, budget requests must be " . . . based on the work to be done, and that staffing needs be established with an accepted workload-based requirements determination process."[2]

With this background, an examination into the Materiel

Distribution Service was accomplished to identify the major functions performed by the various sectional elements. Since any staffing guidance must be related to the actual work performed, workload units were established for each of the major functions. Data collection was performed to determine how many units of each major function were being performed on a daily basis and the number of full time equivalents employed each day. In addition, a series of time studies were performed to determine the average time it took to perform each major task. With this data, an evaluation of actual manpower requirements was accomplished.

It should be noted that while some of the functions in MDS are broadly covered by existing yardsticks (e.g. storage and distribution) in Department of the Army manpower documents, they are not totally applicable to the MDS mission. Work performed in conventional storage and distribution sections of a warehouse have too many dissimilarities with those actions performed by the MDS warehouse; therefore, the existing standards cannot be utilized. This fact is borne out by the fact that previous manpower surveys use local appraisal methods to determine staffing requirements.[3]

Identification of major functions performed by the MDS was determined by reviewing the organizational and functions manual for the hospital, job descriptions of personnel, interviews with both the Chief of Logistics and the supervisor of the MDS, and on-site observations. The observations were also used to determine what sub-routines were required to accomplish a

complete iteration of each major function. Once this information was obtained, data collection sheets to record the time required to perform each sub-routine were prepared by the investigator and submitted to the MDS supervisor for review and comments. Upon completion of his review, appropriate modifications were made to data collection sheets immediately followed by commencement of the time measurement studies.

In addition to the time-measurement data collection sheets prepared by the investigator, daily workload data routinely collected by the MDS supervisor were reviewed to insure that information for each identified major function was being reported. Also, periodic checks were made to insure that workload data was being recorded in a manner consistent with that being used for the time measurement studies. For example, if time measurement studies were based on the amount of time required to exchange, inventory, and replenish each exchange cart, it was necessary to insure that the number of carts exchanged was recorded in workload data versus merely the number of items inventoried.

It should be noted that not all of the tasks performed by the MDS were identified for this study. Many minor tasks are accomplished on an infrequent basis and the amount of time involved was not considered significant. These tasks include activities such as typing administrative letters by the accounting clerk; managing colostomy supplies; breaking down supplies on the warehouse shelf from the unit of issue to unit of measure; straightening shelves; and performing follow-up

action on old requisitions.

Overview of the Blanchfield MDS Section

Several operational aspects of the MDS section need to be discussed to clarify issues that could impact on the study. First, the type of cart employed is important. There are several types of commercially available carts of varying dimensions used both for the exchange cart and par level systems. At this facility, Unicell, Model 27D, manufactured by American Sterilizer Company are used exclusively for the MDS function. Appendix H provides a description of the cell, the various components available, and the cell dimensions. In many cases, multiple cells are required to store the requisite supplies for a particular hospital area.

Secondly, every function in the MDS is performed without any automation support whatsoever. Since the inception of the system at the new facility approximately two years ago, enough experience has been gained so that operational efficiencies have occurred. Based on observations by the investigator while performing time studies, personnel in the MDS section appear to be very knowledgeable and proficient in performing their jobs and have been able to institute a number of procedures to steamline manual operations, particularly in the stock accounting section.

Finally, the Materiel Distribution Service currently operates on a 24-hour, around-the-clock basis throughout the year. This policy was established when the MDS concept was fully initiated concurrent with the movement into the new

facility. The pervading philosophy at the time was continuous service to the customer in exchange for personnel assets to staff the section from the nursing service. With the shift of some personnel assets from the Department of Nursing, it was felt that constant support was necessary for the successful implementation of the cart concept.

The Warehousing Function

The warehousing function has the responsibility to receive, store, and physically distribute the supplies used by the MDS. Both exchange and par level carts are inventoried and replenished by this element on an established schedule that is generally adhered to (Appendix I). For each individual cart, a listing is used that contains the name, stock number and stockage level of each item on the cart printed in the order in which inventories are performed: from left to right on each shelf in a top to bottom manner. The physical location of materiel on the cart is generally determined by the customer. The quantity of each item stocked on the cart is initially determined on a mutual basis between the MDS supervisor and the customer. Thereafter, stockage is generally based on a periodic review of demands.

When a cart is inventoried, the amount of each item counted is compared against the pre-determined stockage level printed on the inventory sheet. If replenishment is necessary, the quantity inventoried is recorded. After the cart inventory process is completed, the quantity of the various items of supply required to reconstitute the cart to the recommended

stockage level are calculated. Supplies are then pulled from the warehouse stockroom and placed on the carts. Although the inventory lists are in the order that items are found on the cart, supplies in the warehouse are in stock number sequence. Frequently, a warehouseman is required to retrace his steps to locate the correct supplies. Generally, at the end of each shift, warehouse personnel post the unit price for each line item of supply issued on the cart listing from a master pricing guide and then transfer the inventory listing to the stock accounting section.

On-call requests for supplies are taken from customers by telephone with delivery service provided by MDS personnel, although customers will occasionally come to the MDS to request and pick up supplies. When a request for supplies is received, the warehouseman prepares an on-call slip which identifies the customer, the item requested, and the quantity desired. Upon receipt of the supplies, a signature from a representative on the ward or clinic is required on the document. In addition to just medical supplies, the MDS provides delivery service for Central Material Service (CMS) and country store items (paper, pencils, etc.). On weekends, an additional on-call service is provided for linens.

An equipment loan pool is managed by the warehouse section for common use items such as intravenous monitors, various medical gas flow meters, humidifiers, blood warmers, etc. When a request is received for a piece of equipment, a temporary hand receipt is prepared and the equipment item delivered to the respective activity. Prior to the release of the

equipment, the warehouseman must obtain a signature from a ward or clinic representative on the hand receipt. Upon return to the warehouse, a copy of the hand receipt document is placed in a file for control purposes. Periodically, the file is reviewed and the customer contacted to determine if the requirement for the equipment still exists.

Stock Accounting Section

The stock accounting section is comprised of three clerks that share the stock management function. Each clerk is responsible for the management of a group of supply items based on a sequential series of national stock numbers. To facilitate the posting of issues, since the inventory lists are not in stock number sequence, each clerk uses a master sheet listing all the stock numbers for which they have responsibility in numerical order. When cart inventory listings and on-call requests are given to the stock accounting personnel, they review only those issues pertinent to their specific stock number categories and annotate the quantity issued beside the respective stock number entry on the master sheet. Upon completion of posting, cart listings are passed to another clerk. After all clerks have accomplished their postings, the inventory lists are passed to the cost accounting clerk.

From the master list, issue quantities are summed for each stock number and a consolidated posting is made to the appropriate stock record. After the issue has been posted, the

stock record card is reviewed to determine whether a reorder point has been reached. If reorder is necessary, computations are made to determine an order quantity necessary to replenish warehouse stocks and a supply request prepared.

To maintain accuracy between the warehouse stocks and the stock accounting records, inventories are periodically performed on a sampling basis or whenever a zero balance is reached. The inventory process is generally performed on a daily basis, time permitting, with a goal of inventorying each of the 1,700 stocked lines at least once every other month.

Supply lists used in support of the supply cart concept are prepared by the stock accounting section. This includes the inventory listings used by the warehouse personnel as well as an alphabetical listing that consolidates all the items found on supply carts for each area. The latter listing is used to assist customers in locating supplies on the carts in the ward and clinic areas. These documents are constantly being revised as items are added or removed from the carts or as carts are reorganized to meet the changing needs of the customer.

Cost Accounting Section

The primary function of the cost accounting section is to maintain financial records of supplies issued to customers. The cost accounting clerk collates the cart issue slips and on-call requests by customer and totals the dollar value of the issues for each document. Upon completion, the total dollar value of the issues to a customer are entered on an accounting

ledger to be used for billing purposes. After all posting is accomplished, the issue slips are then filed. Once a month, a financial report is rendered to the Comptroller for customer billing purposes.

The accounting section is also responsible for updating the pricing guide book used by the warehouse personnel to record unit price and extend item issue costs. A master file is maintained in the MDS office for each stock number that reflects the current unit of issue and unit of measure cost data for each item. When processing receipt documents, the cost accounting clerk verifies the unit of issue price and the conversion factor from unit of measure to unit of issue on each document to insure the data on the master file is correct. Any price or conversion factor change requires the cost accounting clerk to update the card file as well as the master pricing guide used by the warehouse personnel.

Quantitative Research and Analysis Phase

Workload data performed by MDS personnel was collected over a 90-day period of time from 1 October to 30 December. This data was compiled from the daily workload figures as reported by the MDS personnel. Sampling was performed periodically by the investigator to determine the accuracy of the reported workload data. Based on this sampling, no discrepancies were found, and it was determined that the MDS personnel were, in fact, reporting the data accurately. The number of hours worked by the MDS personnel during this time was captured from the time cards for civilian employees and the

MDS supervisor for the few military personnel that work in this section. A listing of the data collected over this 90-day period of time and subsequently used for this study is contained in Appendix J.

From this data, a multiple regression analysis was performed to determine an equation that would best explain the manpower required to perform the MDS function. Each of the major functions were considered independent variables with the number of manhours converted into manday equivalents as the dependent variable. The detailed steps performed in the multiple regression analysis are contained in Appendix K. From this analysis, the following multiple regression equation was determined to be the best model in estimating the manpower required to staff the MDS at Blanchfield Army Community Hospital based on daily workload:

$$Y = -.8518 + .0942X_1 + .1086X_2 + .0306X_3 + .0270X_4 + .0040X_5 + .0148X_6, \text{ where,}$$

Y = the manpower required in terms of full time equivalents
X_1 = the number of carts exchanged
X_2 = the number of par level carts replenished
X_3 = the number of carts cleaned
X_4 = the number of on-call requests processed by the warehouse
X_5 = the number of postings from the master sheet to the accounting records
X_6 = the number of lines inventoried

As the second part of the study, detailed time measurement studies to collect performance data were conducted over an extended period of time commencing in October. At least 62 time measurement studies were performed on each major function

to obtain (statistical significant), average performance times. These studies included the observation of various personnel performing each major function to minimize the impact of collecting all observations from one individual. When possible, the investigator positioned himself in such a manner that MDS personnel did not know who or what major function was being observed. Every attempt was made to minimize the influence of the observer on an individual's performance to insure the times recorded were an accurate reflection of the amount of time required to accomplish a task.

Upon completion of the time performance studies, an analysis was performed to determine the mean time required to perform each major function. This data is provided in Appendix L. To assist in the computation process, all collected times were converted to decimal equivalents to the nearest hundredth of a minute. The average time required to perform each major function was then converted into a fractional manday equivalent. This was accomplished by dividing the average time required to perform a function by the average time an individual is available for productive work or 6.958 hours. Appendix M provides a conversion chart for each of the variables.

Fractional mandays required to perform a major function as determined from the above calculations were used as coefficients to construct an engineered manpower model in the form of an equation. Using this equation will predict the number of mandays necessary to perform the major MDS functions that have been identified on any given day. The engineered equation is as

follows:

$$Y = .0578X_1 + .0040X_2 + .0347X_3 + .0234X_4 + .0306X_5 + .0177X_6 + .0028X_7 + .0018X_8 + .0009X_9 + .0057X_{10} + .0032X_{11} + .0013X_{12} + .0029X_{13} + .0024X_{14} + .0016X_{15} + .0032X_{16},$$

where,

Y = the total manday requirements for the MDS
X_1 = the number of exchange carts replenished
X_2 = the number of receipt documents processed by the warehouse
X_3 = the number of static carts replenished
X_4 = the number of equipment items loaned
X_5 = the number of carts cleaned
X_6 = the number of on-call requests processed
X_7 = the number of lines posted to the master sheet
X_8 = the number of receipt documents posted to the stock records
X_9 = the number of postings from the master sheet to the stock records
X_{10} = the number of requisitions prepared to order stock
X_{11} = the number of lines inventoried
X_{12} = the number of lines typed for inventory or cart stockage lists
X_{13} = the number of inventory lists processed for cost purposes
X_{14} = the number of on-call requests totalled and processed
X_{15} = the number of receipt documents processed for costing purposes
X_{16} = the number of price changes processed

To determine whether there was a statistically significant difference between the engineered model and the multiple regression model, a paired comparison hypothesis test was performed. The daily data collected over the 90-day period was substituted into each equation and the differences in manday requirements between the two calculated. Appendix N details the calculations which indicate that the two equations provide statistically different answers. In particular, the hypothesis

test indicates that the engineered equation based on time performance studies will consistently produce manpower requirements lower than the model built on regression analysis.

While these two models determine the number of full time equivalents per day, they can be extended out to a monthly basis which will provide a clearer indication of the total number of personnel required to operate the MDS since a reduced workforce is employed on weekends. This is accomplished by determining the total number of times each variable is performed in a calendar month and then placing this value in the appropriate location of each model. Calculations are then performed with the answer providing the total number of mandays required in that particular month to perform the MDS function. However, to transform the number of mandays into full time equivalents, this answer must be divided by the number of standard workdays one full time equivalent would be expected to work during the month (assuming a forty-hour week, working Monday through Friday). Table 2 demonstrates a comparison of the number of full time equivalents required on a monthly basis employing the two models using the three months' data collected for the study.

TABLE 2

THE CALCULATION AND COMPARISON OF FULL TIME EQUIVALENTS ON A MONTHLY BASIS USING THE MULTIPLE REGRESSION AND ENGINEERED MODELS

MONTH	NO. OF WORKDAYS IN THE MONTH	TOTAL DAILY MANDAYS		FTEs REQUIRED		DIFFERENCE	
		MR EQ*	ENG EQ**	MR EQ*	ENG EQ**	MR - ENG	
OCT	22	333.57	272.56	15.16	12.39	2.77	23.16%
NOV	20	298.04	248.87	14.90	12.44	2.46	19.95%
DEC	20	275.44	224.26	13.77	11.21	2.56	22.85%

* MR EQ = Multiple Regression Model

** ENG EQ = Engineered Model

Using the engineered equation as a baseline, the difference in staffing requirements of the two models, on the average, is approximately twenty percent. This value is considered significant based on the criteria established for this study.

Considering the MDS has an authorized staffing level of 16 full time equivalents to support the production of 713 average daily MCCUs, it is interesting to note that the number of full time equivalents, based on the models for each of the three months evaluated in this study, was less than the number authorized, although the average daily workload was well above 800 MCCUs. If the workload was to exceed the authorized staffing level, it would be reasonably assumed that additional personnel might be required, although this was not the case.

At no time did either model predict staffing at a level greater than 16 FTEs.

ENDNOTES

[1]Interview with Ms. Joan Chandler, Director, Materiel Distribution, Vanderbilt University Hospital, Nashville, Tennessee, 30 April 1985.

[2]Manpower Staffing Standards Systems, Army Regulation 570-4 (Washington, D.C.: Government Printing Office, 1974): p. 3-1.

[3]Interview with Mr. Vincent Mack, Chief, Manpower Survey Section, Force Development Division, US Army Health Services Command, Fort Sam Houston, Texas, 2 July 1985.

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The fact that the two developed models will provide significantly different results is not alarming. The engineered standard derived from the time measurement analysis indicates the staffing level required to perform only the major functions identified in the study. Because the multiple regression model provides an explanation of variability between collected workload data versus the number of personnel that were on hand to perform the functions each day of the data collection period, the time required to accomplish many minor, unmeasured tasks are inherently included in this model. In addition, the final regression equation excludes some of the major functions that were originally identified in the study. This is a consequence of developing a model that contains only statistically significant variables. With a coefficient of determination value of 93 percent, a significant amount of variation is explained by the regression model, leaving seven percent to account for the accomplishment of minor tasks not included in the study as well as the major tasks removed from the final regression equation.

Unequivocally, the engineered model represents the minimum staffing necessary to perform all the identified major functions. There is no allowance for the performance of any

other minor tasks.

On the other hand, the multiple regression equation serves as a predictor of how much manpower is required based on the variability of performing the major functions versus the amount of manpower consumed to accomplish the tasks. The fact that the major functions, as well as many minor non-measured activities were accomplished in the number of hours recorded over the ninety day period causes one to reflect whether the multiple regression equation might predict a maximum number of full time equivalents necessary to accomplish the MDS function. This concept is further substantiated by the fact that during the period of data collection, the MDS was providing customer support in a satisfactory manner as evidenced by the lack of complaints by the customers. Therefore, the use of this model can be used to provide the upper range of manpower required to perform the MDS function.

To determine the range of manpower required on a day-to-day basis, a comparison of the number of full time equivalents between the two models was accomplished by taking the data collected over the ninety day period and applying it against the two models (Appendix O). In 88 out ofn 90 cases, the number of FTEs required based on the multiple regression model exceeded that number as calculated in the engineered model. In the two isolated cases, the difference was negligible. This indicates that the MDS section is consistently overstaffed; however, the degree of overstaffing on a daily basis may be somewhat overstated since the

engineered equation contains just those major tasks that were identified in the study.

Applying the data on a monthly basis to more clearly define the actual number of personnel requirements based on the two models (since the MDSs operates seven days a week), it was determined that a difference existed between the two models of approximately two and one half FTEs. More notable, though, is the fact that the maximum number of FTEs required (as calculated by using the regression equation) was at least one FTE less than the sixteen authorized personnel determined by the manpower survey. In addition, there are probably additional excesses; however, the actual number of positions the MDS can be reduced beyond the one identified is left up to the command. The actual figure lies somewhere between the minimum and maximum levels as determined by the two models.

Using the two models simultaneously against predicted or historical data, an upper and lower limit of the manpower necessary to support the MDS function can now be defined. This provides latitude to the hospital to determine at what level staffing should be accomplished. The actual number of full time equivalents is ultimately a management decision by the command; however, definitive parameters can now be determined and not left solely up to conjecture.

Recommendations

Based on this study, the following recommendations are made regarding the MDS staffing:

1. At least one FTE should be removed from the MDS

staffing level. The fact that on a monthly basis, the multiple regression model consistently demonstrates a manpower requirement in excess of the engineered model by at least one full time equivalent, a reduction of the MDSs work force by a like amount is indicated. An additional reduction of one position is encouraged to help bring the manpower differences between the two models into closes alignment and should result in little or no disruption of services.

2. Based on the conclusion that a higher and lower limit can be established to determine manpower requirements, it is recommended that a periodic assessment be made of the MDS section to check the status of the work force.

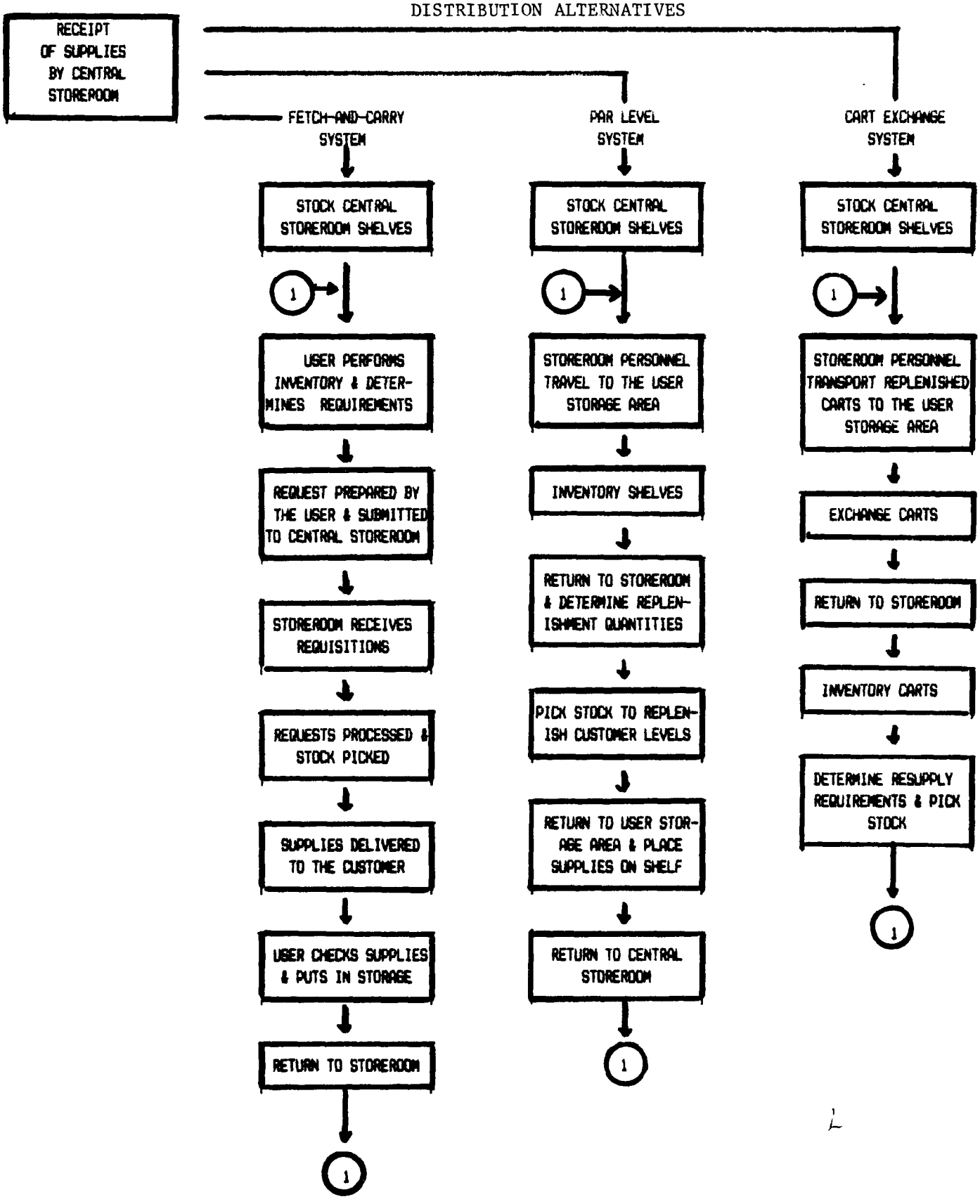
3. The 24-hour-a-day operational concept be evaluated to determine if efficient use of manpower is being accomplished, especially on the night shift.

4. Since many of the tasks in the stock accounting and cost accounting functions can be performed effectively and more efficiently with a computer, automation support should be considered. Upon completion of an automation project, a new study should be conducted as the implementation of a new technology will certainly affect the current models.

APPENDIX A

DISTRIBUTION ALTERNATIVES

DISTRIBUTION ALTERNATIVES

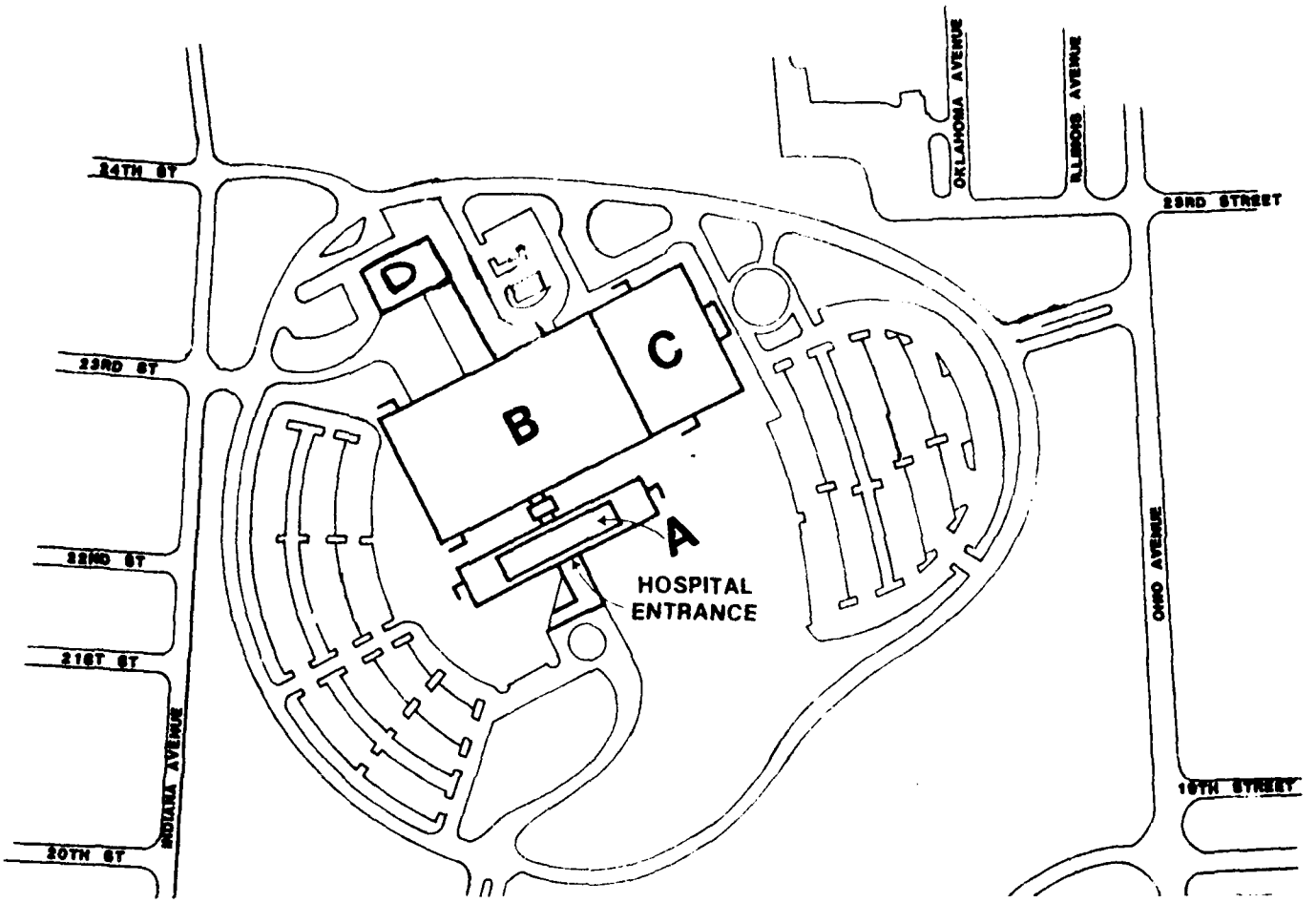


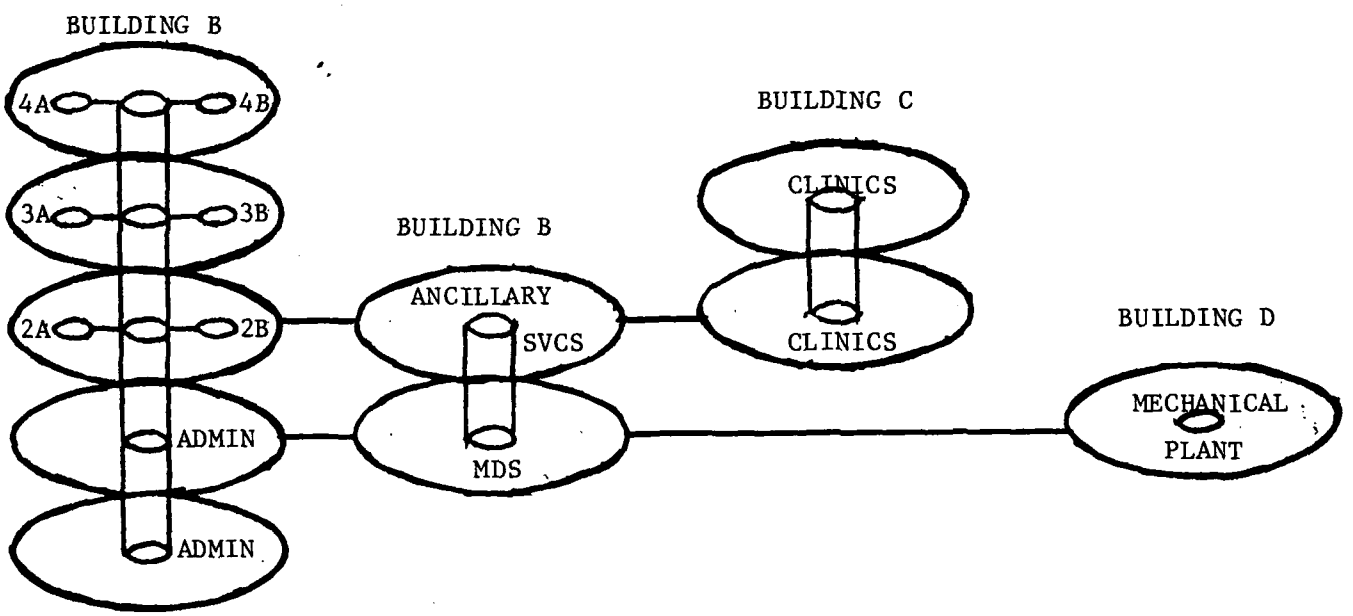
APPENDIX B

DESIGN AND ELEVATION OF THE

COLONEL FLORENCE A. BLANCHFIELD ARMY COMMUNITY HOSPITAL

COL FLORENCE A. BLANCHFIELD ARMY COMMUNITY HOSPITAL



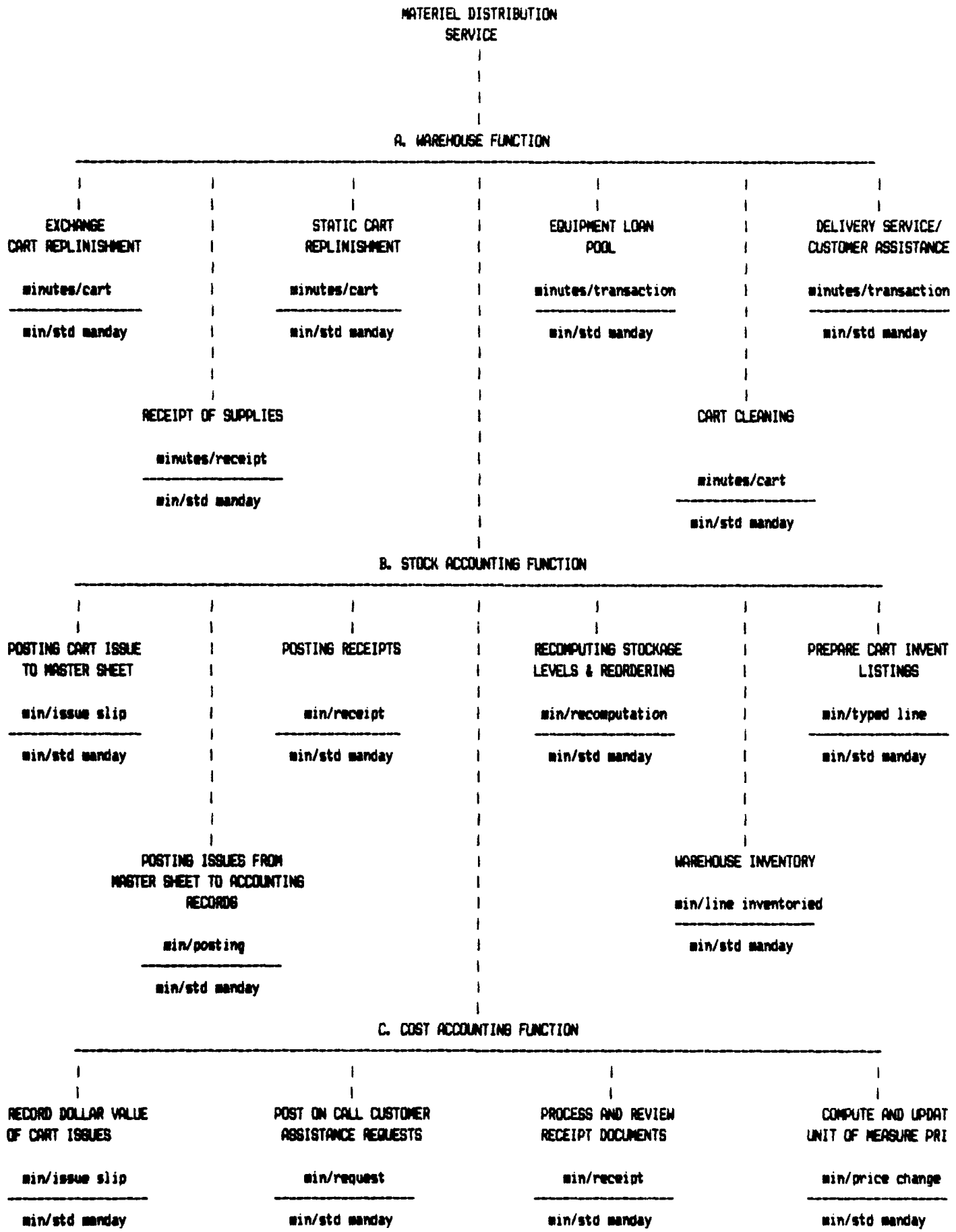


ELEVATION OF BUILDINGS

APPENDIX C

MATERIEL DISTRIBUTION SERVICE

MAJOR FUNCTIONS AND SUBROUTINES


MATERIEL DISTRIBUTION SERVICE
A. WAREHOUSE FUNCTION
EXCHANGE CART REPLINISHMENT
minutes/cart
min/std manday
STATIC CART REPLINISHMENT
minutes/cart
min/std manday
EQUIPMENT LOAN POOL
minutes/transaction
min/std manday
DELIVERY SERVICE/ CUSTOMER ASSISTANCE
minutes/transaction
min/std manday
RECEIPT OF SUPPLIES
minutes/receipt
min/std manday
CART CLEANING
minutes/cart
min/std manday
B. STOCK ACCOUNTING FUNCTION
POSTING CART ISSUE TO MASTER SHEET
min/issue slip
min/std manday
POSTING RECEIPTS
min/receipt
min/std manday
RECOMPUTING STOCKAGE LEVELS & REORDERING
min/recomputation
min/std manday
PREPARE CART INVENT LISTINGS
min/typed line
min/std manday
POSTING ISSUES FROM MASTER SHEET TO ACCOUNTING RECORDS
min/posting
min/std manday
WAREHOUSE INVENTORY
min/line inventoried
min/std manday
C. COST ACCOUNTING FUNCTION
RECORD DOLLAR VALUE OF CART ISSUES
min/issue slip
min/std manday
POST ON CALL CUSTOMER ASSISTANCE REQUESTS
min/request
min/std manday
PROCESS AND REVIEW RECEIPT DOCUMENTS
min/receipt
min/std manday
COMPUTE AND UPDAT UNIT OF MEASURE PRI
min/price change
min/std manday

APPENDIX D

SUBROUTINE PERFORMANCE TIME

COLLECTION SHEETS

EXCHANGE CART REPLENISHMENT FUNCTION
TIME WORKSHEET

CART NUMBER: _____ DATE OF TEST: _____

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. PICK UP USED CART, REPLACE WITH REPLENISHED CART			
2. INVENTORY ITEMS ON CART AND COMPUTE REPLENISHMENT QUANTITIES			
3. PULL REPLENISHMENT STOCK FOR CART			
4. PLACE STOCK ON CARTS			
5. PRICE ISSUES & EXTEND COST DATA			
TOTAL TIME FOR CART RECONSTITUTION CYCLE			

PROCESSING SUPPLY RECEIPTS

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. VERIFY RECEIPT QUANTITY WITH SHIPPING DOCUMENT			
2. CONVERT UNIT OF ISSUE INTO UNIT OF MEASURE			
3. LOCATE AND PLACE MATERIEL ON WAREHOUSE SHELF			
TOTAL TIME TO PERFORM FUNCTION			

STATIC CART REPLENISHMENT FUNCTION
TIME WORKSHEET

CART NUMBER: _____ DATE OF TEST: _____

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. GO TO AREA AND INVENTORY ITEMS ON THE CART			
2. COMPUTE REPLENISHMENT QUANTITIES			
3. RETURN TO WAREHOUSE AND PULL REPLENISHMENT STOCK FOR CART			
4. TAKE STOCK FROM THE WAREHOUSE TO THE CART			
5. PRICE ISSUES & EXTEND COST DATA			
TOTAL TIME FOR CART RECONSTITUTION CYCLE			

EQUIPMENT LOAN POOL

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. RECEIVE CUSTOMER REQUEST			
2. DETERMINE IF ITEM IS AVAILABLE			
3. PREPARE DD FORM 1150 (TEMPORARY HAND RECEIPT)			
4. FILE TEMPRARY HAND RECEIPT			
TOTAL TIME TO PERFORM FUNCTION			

CART CLEANING FUNCTION

CART NUMBER/DESCRIPTION	DATE	TIME BEGIN	TIME END	TOT TIME ELAPSED

DELIVERY SERVICE/CUSTOMER ASSISTANCE

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

DELIVERY SERVICE/CUSTOMER ASSISTANCE (CONT)

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					

DELIVERY SERVICE/CUSTOMER ASSISTANCE (CONT)

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
61					
62					

AVERAGE TIME PER EACH DELIVER, CUSTOMER ASSISTANCE ACTION	

POSTING CART ISSUES TO MASTER SHEET

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. POST CART AND ON-CALL ISSUES TO MASTER LIST			
2. AUTHENICATE POSTING OF THE ISSUE DOCUMENT			
TOTAL TIME TO POST AN ISSUE DOCUMENT TO MASTER RECORDS			

POSTING ISSUES FROM MASTER SHEET TO ACCOUNTING RECORDS

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. LOCATE THE ACCTNG RECORD FOR THE STOCK NUMBER			
2. POST THE ISSUED QTY TO THE ACCOJNTING RECORD			
3. DETERMINE WHETHER RE-ORDER IS NECESSARY			
TOTAL TIME TO PERFORM FUNCTION			

POSTING STOCK RECEIPTS TO STOCK RECORDS

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. LOCATE DD FORM 3318, STOCK RECORD			
2. VERIFY THE MATERIEL IS DUE-IN, POST THE RECEIVED QUANTITY			
3. UPDATE DOCUMENT REGISTER TO REFLECT RECEIPT AND ADJUST D/I STATUS ON 3318			
TOTAL TIME TO POST AN ISSUE DOCUMENT TO MASTER RECORDS			

RECOMPUTING STOCKAGE LEVELS & REORDERING

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. RECOMPUTE STOCKAGE LEVEL			
2. DETERMINE QUANTITY NEEDED TO RECONSTITUTE SHELF STOCK			
3. PREPARE REQUISITION TO REPLENISH STOCK			
4. PREPARE ENTRY IN DOCUMENT REGISTER TO RECORD DOC NO.			
5. FILE A COPY OF THE REQUEST IN THE SUSPENSE FILE			
TOTAL TIME TO PERFORM FUNCTION			

WAREHOUSE INVENTORY

SUBROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. COUNT QUANTITY ON SHELF			
2. VERIFY THAT ANY ISSUES IN-TRANSIENT ARE ACCOUNTED FOR AND ADJUSTMENTS MADE			
3. COMPARE COUNT QUANTITY WITH RECORDED BALANCES			
4. MAKE APPROPRIATE ENTRY TO BALANCE RECORDED QUANTITY WITH COUNT QUANTITY			
TOTAL TIME TO PERFORM FUNCTION			

PREPARING CART LISTINGS (LINES)

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

PREPARING CART LISTINGS (CONT)

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					

PREPARING CART LISTINGS (CONT)

OBSERVATION NUMBER	STOCK CLERK	TIME BEGIN	TIME FINISHED	ELAPSED TIME	DATE OF OBS
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
61					
62					

AVERAGE TIME PER LINE TYPED	

RECORD DOLLAR VALUE OF CART ISSUES

SUB-ROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. VERIFY THE EXTENDED DOLLAR VALUES ON EACH ITEM			
2. TOTAL THE EXTENDED DOLLAR VALUES			
3. ENTER THE TOTAL ON LEDGER FOR BILLING PURPOSES & FILE THE ISSUE			
TOTAL TIME TO POST CART ISSUES TO RECORDS			

POST ONCALL CUSTOMER REQUESTS

SUBROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. TOTAL THE AMOUNT OF THE ISSUE			
2, FIND THE CUSTOMER LEDGER AND POST THE ISSUE			
TOTAL TIME TO POST ONCALLS TO FINANCIAL RECORDS			

POSTING MATERIEL RECEIPTS

SUBROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. REDUCE THE DOLLAR VALUE MATERIEL DUE-IN			
2. ADD THE DOLLAR VALUE OF THE RECEIPT TO THE CURRENT INVENTORY BALANCE			
3. FILE THE RECEIPT DOCUMENT			

COMPUTE AND UPDATE UNIT OF MEASURE PRICE

SUBROUTINE	TIME BEGIN	TIME FINISHED	ELAPSED TIME
1. COMPUTE THE UNIT OF MEASURE			
2. COMPUTE THE UNIT OF MEASURE PRICE			
3. UPDATE RECORDS			
TOTAL AMOUNT OF TIME TO COMPUTE AND UPDATE UNIT OF MEASURE PRICE			

APPENDIX E

STATISTICAL DERIVATION FOR THE NUMBER OF OBSERVATIONS REQUIRED TO EVALUATE EACH FUNCTION

STATISTICAL DERIVATION - NUMBER OF OBSERVATIONS REQUIRED

To determine the number of observations required for the purposes of this research, the following formula was used:

$$n = \frac{z^2 \ s^2}{d^2}$$, where

n = the number of observations required
z = the confidence coefficient for the standard normal curve
s = the standard deviation of the sample, and
d = the distance from the true mean of the population.

The criteria for this study stated that an interval within 1/4 standard deviation from the true mean will be used to determine the sample size. Substituting 1/4 s for d, the equation becomes:

$$n = \frac{z^2 \ s^2}{(1/4 \ s)^2}$$

Cancelling out the s^2 in the numerator and denominator, the equation becomes:

$$n = \frac{z^2}{.0625} \quad \text{or} \quad n = 16z^2$$

With a confidence coefficient of .95, the z value is 1.96; therefore,

$$16 \text{ X } (1.96)^2 = 16 \text{ X } 3.8416 = 61.46,$$

or 62 observations of each function.

NOTE: The formula and confidence coefficient were obtained from Biostatistics: A Foundation for Analysis in the Health Sciences by Wayne W. Daniel.

APPENDIX F

STAFFING RESULTS FROM THE MOST RECENT MANPOWER SURVEY

The survey team recommended a total of 1370 personnel requirements to operate the entire medical mission at Fort Campbell, including the dental, preventive medicine, and veterinarian functions. (see attached survey documentation) To determine the number of recognized positions at the hospital, the total figure must be adjusted as indicated below:

TOTAL MANPOWER FOR THE MEDICAL MISSION:		1370
LESS,		
DENTAL ACTIVITY	208	
ALCOHOL, DRUG ABUSE PREVENTION AND CONTROL PROGRAM (ADAPCP)	16	
VETERINARY SERVICE	52	
PREVENTIVE MEDICINE SERVICE	42	
TOTAL		318
RECOGNIZED MANPOWER ALLOCATION FOR THE HOSPITAL:		1052

Based on the recognized level of staffing, the manpower survey team projected that the hospital should produce an average of 912.5 average daily Medical Care Composite Units (MCCUs). The US Army Health Services Command authorized personnel allocations at 80.7 of the recognized strength. Using a straight line approximation, with an authorized staffing level of 852 personnel, the hospital should be producing 739 average daily MCCUs.

MANPOWER SURVEY REPORT - REMARKS
For use of this form, see AR 570-4; the proponent agency is Office of the Assistant Chief of Staff for Force Development.

1. SHEET NO.	2. LINE NO.	REPORTS CONTROL SYMBOL CSFOR-76

3. CHECK APPLICABLE BLOCK. X SURVEY TEAM GENERAL REMARKS (Complete item 4, only, and file after Commander's General Remarks.)
COMMANDER GENERAL REMARKS (Complete item 4, only, and file after Coversheet, DA Form 140.)
SURVEY TEAM SPECIFIC REMARKS (If this block is checked, complete items 1, 2, and 4 and file with Schedule X.)

4. REMARKS: (If more space is required, continue on plain paper 10½" x 8".)

a. This manpower survey was conducted at Fort Campbell MEDDAC/DENTAC during the period 25 October 1983 - 9 November 1983 by representatives of Headquarters, United States Army Health Services Command. Members of the survey team were:

MR. VINCENT H. MACK, TEAM CHIEF
MAJ (P) KATHRYN DEUSTER, ANC
MAJ GEORGE H. TOUCHARD, MSC
MAJ JAMES H. COFFMAN, MSC
MAJ RUTH REA, ANC
MSG JOSEPH E. STADLER
MR. JOHN D. ASBELL
MS. MARILYN J. LUTHER
MR. JAMES B. WALKER
MS. SHERRY R. WRIGHT

b. Initial manpower requirements were:

OFF	WO	ENL	CIV	OTHERS	TOTAL
265	3	440	666	35	1409

c. Initial manpower allocations were:

OFF	WO	ENL	CIV	TOTAL
187	2	357	553	1099

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FOR EXAMPLES AND INSTRUCTIONS, SEE APPENDIX B, DA PAMPHLET 570-4.

DA FORM 1 DEC 73 140-1

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

* U.S. GPO: 1974—540-842/8623

SURVEY TEAM GENERAL REMARKS, CONTINUATION SHEET

d. The commander's recommended requirements were:

OFF	WO	ENL	CIV	OTHERS	TOTAL
298	5	489	745	16	1553

e. The survey team's recommended requirements were:

OFF	WO	ENL	CIV	OTHERS	TOTAL
268	6	418	659	19	1370

f. Where applicable, in addition to specific workloads reported on the Medical Summary Report (MED-302) (as verified or amended on-site), the following statistics were used by the survey team in considering manpower recommendations:

(1) Population Supported (as of 30 September 1983):

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	Ft Campbell	Defense Depot Memphis
Active Duty - Army TDA	1,963	25
Active Duty - Army TOE	19,868	
Active Duty - Other Services	165	9
USAR in Tng	572	
Students	200	
Retired	27,654	
Family Members - On Post (Active Duty)	10,835	
Family Members - Off Post (Active Duty)	10,861	
Family Members - Retired - Off Post	68,777	
Civilian Employees - Civil Service	4,242	2,623
Civilian Employees - NAF, Other	873	12

SURVEY TEAM GENERAL REMARKS, CONTINUATION SHEET

(2) Other Data (average for the survey months, 1 Jan - 30 Sep 83).

MCCU	912.5
Admissions	24.8
Occ Beds	145.1
Clinic Visits	1,584.6
Live Births	4.4

includes 118 births and 11 C-Section. (Birth D.O. .4 C section)

g. The survey team took note of the commander's remarks regarding a projected increase in the population supported by the MEDDAC and the return of many former CHAMPUS patients. In as much as present state of the art survey methodologies are not sophisticated enough to derive total valid impacts (including impacts in administrative and support areas) from such projections, the survey team based this survey on the current validated population supported figures listed at paragraph f(1) above and historical workload through September 1983. As actual measurable workloads result in demonstratable increases in staffing requirements over present recommended levels, interim Schedules X should be submitted to reflect such changes.

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h. Within the policy guidance of AR 570-4, Letter HQDA, DASG-RMM(M), 570-80-4, dated 30 December 1982, Subject: Staffing Authorization and Utilization of Army Medical Department Personnel in MTOE Units (Short Title: MEDO Letter), and in consonance with the Memorandum of Understanding between CDR, USAFORSCOM, CDR, USATRADOC, and CDR, USAHSC, 23 September 1982, the team chief met with the Commander, 326th Medical Battalion and the Division Surgeon, 101st Airborne Division, and inquired into the availability of AMEDD TOE personnel for utilization in MEDDAC/DENTAC functional areas of responsibility. As reflected on the Schedule T and Inclosure 1 to these general remarks, the survey team has quantified and recommended 19 TOE man-year equivalents.

1 Incl
as

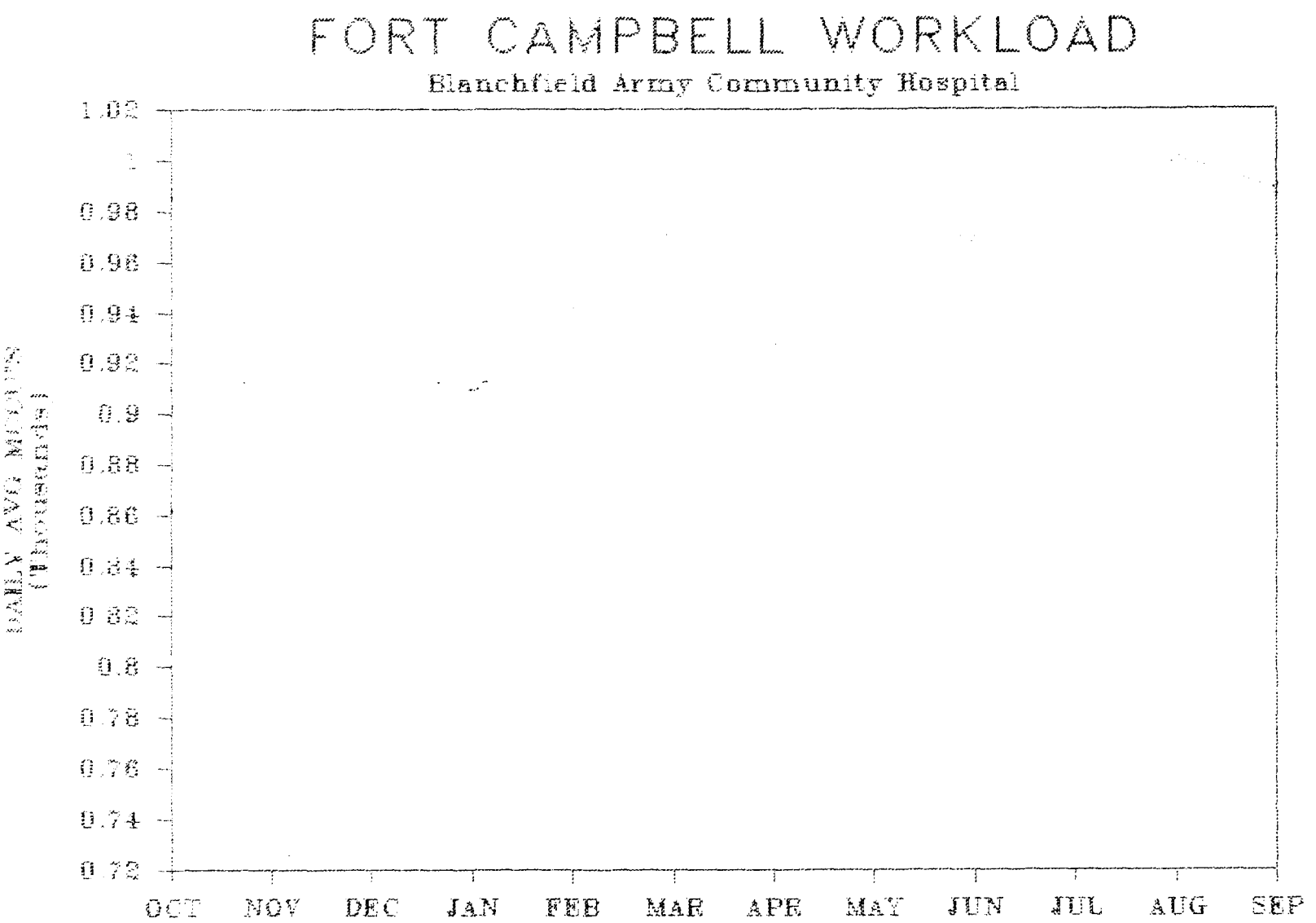
APPENDIX G

AVERAGE DAILY MEDICAL CARE COMPOSITE UNITS

PRODUCED BY THE COLONEL FLORENCE A. BLANCHFIELD

ARMY COMMUNITY HOSPITAL

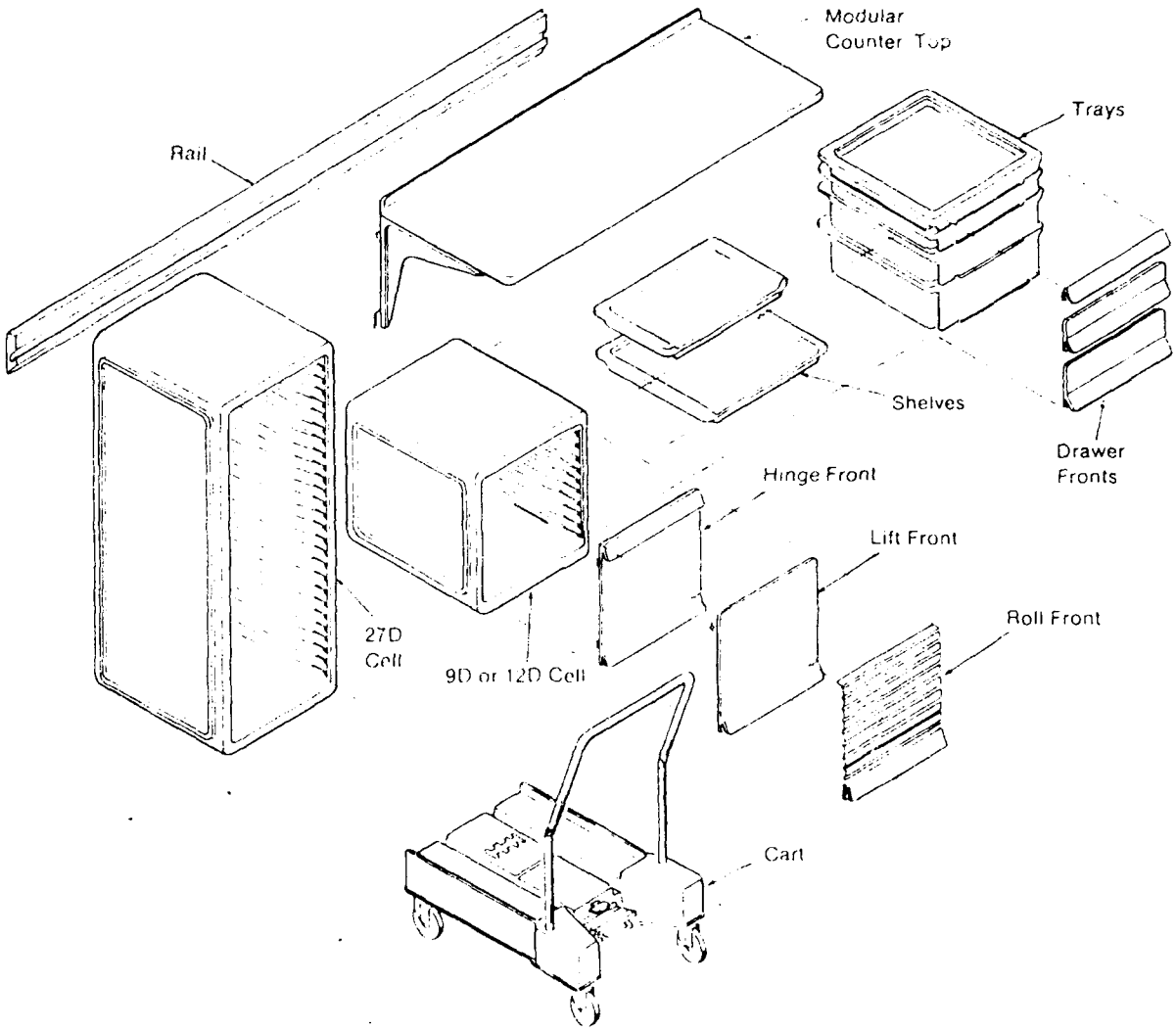
FY 1984 AND THE FIRST SIX MONTHS OF FY 1985


FORT CAMPBELL WORKLOAD
Blanchfield Army Community Hospital
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
0.78
0.76
0.74
0.72
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

APPENDIX H

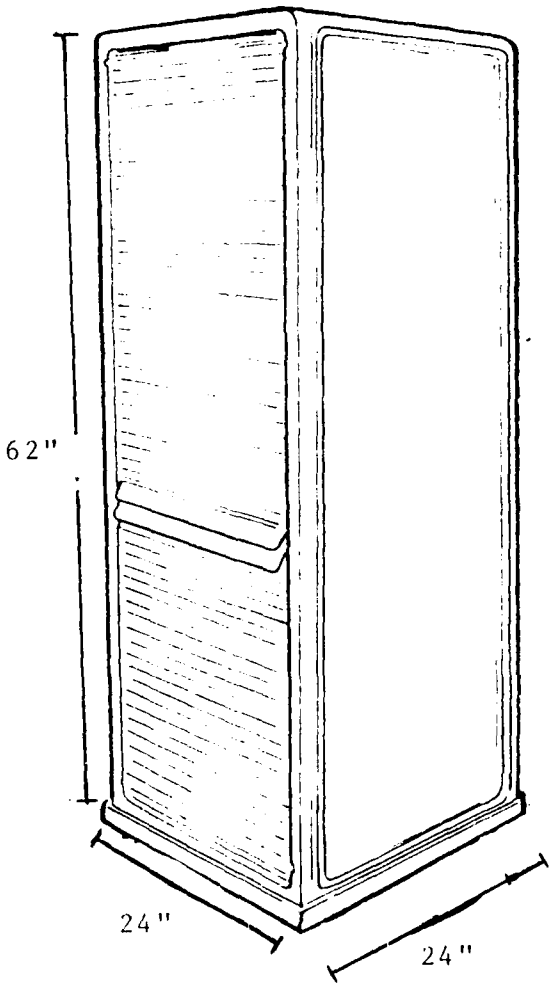
EXCHANGE CARTS USED AT BLANCHFIELD ARMY COMMUNITY HOSPITAL: SPECIFICATIONS AND COMPONENTS

UNICELL COMPONENTS

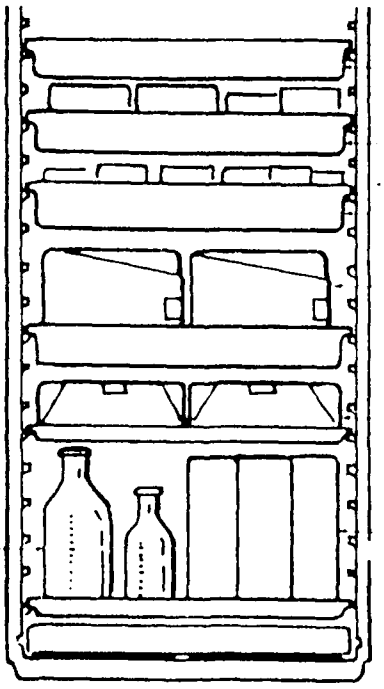


The basic component is a Cell (various sizes available). Shelves and Trays may be inserted into the Cell at desired heights. A variety of Cell front covers are available to protect contents from environmental contaminants. A cart provides the means for transporting Cells from one location to another.

27D Cell



27D Cell



APPENDIX I

CART REPLENISHMENT SCHEDULE

EXCHANGE CART SCHEDULE

	NUMBER OF CELLS	MWF	T/TH	SAT/SUN HOLIDAYS
OPERATING ROOM	5	5	5	
ANESTHESIA	3	3	3	
RECOVERY ROOM	2	2	2	
RADIOLOGY	2	2	2	
PHYSICAL THERAPY	2	2		
UROLOGY	3	3	3	
FAMILY PRACTICE	4	0	4	
PEDIATRIC CLINIC	2	2	2	
OB/GYN CLINIC	3	3	3	
PHYSICAL EXAM	1	1	1	
TMC 1	1		1	
ORTHOPEDIC CLINIC	2	2	2	
PODIATRY CLINIC	1	1	1	
ENT CLINIC	2	2	2	
GENERAL MEDICINE CLINIC	2	2	2	
DERMATOLOGY CLINIC	1		1	
ALLERGY CLINIC	1	1	1	
IMMUNIZATION CLINIC	1	1	1	
SURGICAL CLINIC	3	3		
INHALATION THERAPY	1	1	1	
LABOR/DELIVERY	4	4	4	4
POST PARTUM	3	3	3	3
NEWBORN NURSERY	2	2	2	2
PEDIATRIC WARD	4	4	4	4
ORTHOPEDIC WARD	3	3	3	3
MEDICINE WARD	3	3	3	3
SURGICAL WARD	4	4	4	4
INTENSIVE CARE UNIT	5	5	5	5
EMERGENCY ROOM	6	6	6	6
TOTAL CARTS	76	70	71	34

STATIC (PAR LEVEL) SCHEDULE

	NUMBER OF CELLS	MWF	T/TH	SAT/SUN HOLIDAYS
CMS	2	2	2	
NEWBORN NURSERY STATIC	1	1	1	
LABOR/DELIVERY STATIC	1	1	1	1
ICU STATIC	1	1	1	1
PEDIATRIC WARD STATIC	1	1	1	1
POST PARTUM STATIC	1	1	1	1
PSYCHIATRIC WARD	2	2		
OPERATING ROOM	2	2	2	2
RADIOLOGY	1	1		
LABORATORY	1	1	1	1
UROLOGY CLINIC	2	2		
PEDIATRIC CLINIC	1	1	1	
EMERGENCY ROOM	1	1	1	1
EMERGENCY ROOM ORTHO	1	1	1	1
ORTHOPEDIC CLINIC	2	2	2	
EKG CLINIC	1	1		
EYE CLINIC	2	2	1	
BRACE SHOP	5	5	5	
TOTAL CARTS	28	28	21	9

APPENDIX J

NINETY DAY WORKLOAD DATA FOR THE MATERIEL DISTRIBUTION SERVICE

SUMMARY DATA COLLECTION SHEET (1 - 7 OCTOBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	3	2	178	38	60	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	9	4	8	6	11	0	3
# OF CARTS CLEANED	4	3	2	72	4	7	7
# OF ON CALLS & DELIVERY REQUESTS	72	112	77	75	120	33	26
# OF ITEMS POSTED TO MASTER SHEET	1232	768	674	823	890	0	0
# OF RECEIPTS POSTED TO RECORDS	3	4	127	37	66	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	490	364	352	383	353	0	0
# OF ITEMS HAVING RQ RECOMPUTED	39	60	24	43	55	0	0
# OF LINES INVENTORIED	35	45	69	40	45	0	0
# OF LINES TYPED FOR INVENTORY LISTS	271	20	41	352	328	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	122	44	41	44	0	0
# OF ON CALL REQUESTS POSTED	0	131	112	77	75	0	0
# OF RECEIPTS PROCESSED AND FILED	0	0	0	0	103	0	0
# OF PRICE CHANGES PROCESSED	0	0	1	0	34	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	110	118	111	121	112	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13.75	14.75	13.875	15.125	14	4	4

SUMMARY DATA COLLECTION SHEET (8 - 14 OCTOBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	34	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	0	81	52	48	44	0	0
# OF STATIC CARTS REPLENISHED	9	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	0	7	6	3	5	2	4
# OF CARTS CLEANED	6	0	3	55	4	8	7
# OF ON CALLS & DELIVERY REQUESTS	18	74	69	97	64	31	45
# OF ITEMS POSTED TO MASTER SHEET	180	1447	595	859	782	0	0
# OF RECEIPTS POSTED TO RECORDS	0	63	42	34	30	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	63	675	275	377	402	0	0
# OF ITEMS HAVING RO RECOMPUTED	0	31	35	25	30	0	0
# OF LINES INVENTORIED	0	30	44	3	61	0	0
# OF LINES TYPED FOR INVENTORY LISTS	0	0	707	540	0	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	95	41	44	41	0	0
# OF ON CALL REQUESTS POSTED	0	183	79	74	69	0	0
# OF RECEIPTS PROCESSED AND FILED	0	0	187	45	23	0	0
# OF PRICE CHANGES PROCESSED	0	0	59	11	6	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	40	103	103	112	110	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	5	12.875	12.875	14	13.75	4	4

SUMMARY DATA COLLECTION SHEET (15 - 21 OCTOBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	50	58	2	104	38	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	10	0	7	6	6	0	1
# OF CARTS CLEANED	0	3	4	8	8	7	2
# OF ON CALLS & DELIVERY REQUESTS	72	73	96	49	56	26	28
# OF ITEMS POSTED TO MASTER SHEET	1320	882	745	689	693	0	0
# OF RECEIPTS POSTED TO RECORDS	47	40	3	38	79	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	624	587	382	373	407	0	0
# OF ITEMS HAVING RO RECOMPUTED	47	65	56	30	57	0	0
# OF LINES INVENTORIED	40	60	70	90	104	0	0
# OF LINES TYPED FOR INVENTORY LISTS	91	390	767	215	224	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	78	44	41	44	0	0	0
# OF ON CALL REQUESTS POSTED	135	72	73	96	0	0	0
# OF RECEIPTS PROCESSED AND FILED	34	46	66	1	0	0	0
# OF PRICE CHANGES PROCESSED	6	12	13	1	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	88	104	112	127	92	24	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	11	13	14	15.875	11.5	3	4

SUMMARY DATA COLLECTION SHEET (22 - 28 OCTOBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	22	83	1	100	71	1	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	5	6	9	9	4	2	0
# OF CARTS CLEANED	3	3	0	52	3	2	5
# OF ON CALLS & DELIVERY REQUESTS	61	79	87	83	77	28	37
# OF ITEMS POSTED TO MASTER SHEET	1492	685	697	468	455	0	0
# OF RECEIPTS POSTED TO RECORDS	33	20	73	4	0	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	448	384	380	292	231	0	0
# OF ITEMS HAVING RD RECOMPUTED	54	62	47	47	17	0	0
# OF LINES INVENTORIED	32	73	68	74	32	0	0
# OF LINES TYPED FOR INVENTORY LISTS	44	96	359	330	0	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	87	105	66	41	0	0
# OF ON CALL REQUESTS POSTED	0	120	140	87	83	0	0
# OF RECEIPTS PROCESSED AND FILED	0	0	161	0	91	0	0
# OF PRICE CHANGES PROCESSED	0	0	31	0	8	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	96	111	102	127	101	24	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	12	13.875	12.75	15.875	12.625	3	4

SUMMARY DATA COLLECTION SHEET (29 OCT - 4 NOV 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	45	51	77	4	0	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	9	6	6	6	7	0	1
# OF CARTS CLEANED	16	3	17	19	5	9	4
# OF ON CALLS & DELIVERY REQUESTS	62	99	79	75	80	32	32
# OF ITEMS POSTED TO MASTER SHEET	1539	770	802	761	783	0	0
# OF RECEIPTS POSTED TO RECORDS	25	88	76	31	3	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	739	373	355	340	83	0	0
# OF ITEMS HAVING RO RECOMPUTED	98	49	24	75	53	0	0
# OF LINES INVENTORIED	30	0	0	5	69	0	0
# OF LINES TYPED FOR INVENTORY LISTS	60	72	52	0	231	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	34	88	41	44	41	0	0
# OF ON CALL REQUESTS POSTED	142	62	99	79	75	0	0
# OF RECEIPTS PROCESSED AND FILED	0	167	24	37	70	0	0
# OF PRICE CHANGES PROCESSED	0	16	4	2	8	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	113	108	111	118	101	28	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	14.125	13.5	13.875	14.75	12.625	3.5	4

SUMMARY DATA COLLECTION SHEET (5 - 11 NOVEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	165	57	93	23	4	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	6	11	7	15	7	0	1
# OF CARTS CLEANED	22	3	3	30	3	6	4
# OF ON CALLS & DELIVERY REQUESTS	62	99	117	69	71	35	49
# OF ITEMS POSTED TO MASTER SHEET	1543	730	560	1183	975	0	0
# OF RECEIPTS POSTED TO RECORDS	16	96	13	81	12	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	740	349	251	512	367	0	0
# OF ITEMS HAVING RO RECOMPUTED	76	50	12	74	71	0	0
# OF LINES INVENTORIED	30	26	2	2	75	0	0
# OF LINES TYPED FOR INVENTORY LISTS	160	158	20	145	0	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	88	0	0	0	143	0	0
# OF ON CALL REQUESTS POSTED	144	0	0	0	168	0	0
# OF RECEIPTS PROCESSED AND FILED	34	0	0	0	0	0	0
# OF PRICE CHANGES PROCESSED	3	0	0	0	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	107	104	90	96	93	24	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13.375	13	11.25	12	11.625	3	4

SUMMARY DATA COLLECTION SHEET (12 - 18 NOVEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	34	71	70	71	74	34	34
# OF LINES RECEIVED AND WAREHOUSED	0	64	69	57	4	0	0
# OF STATIC CARTS REPLENISHED	9	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	1	8	12	12	11	0	1
# OF CARTS CLEANED	3	19	0	3	3	6	7
# OF ON CALLS & DELIVERY REQUESTS	26	77	93	76	56	32	20
# OF ITEMS POSTED TO MASTER SHEET	0	1889	436	1000	652	0	0
# OF RECEIPTS POSTED TO RECORDS	0	71	72	27	39	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	0	541	214	360	372	0	0
# OF ITEMS HAVING RQ RECOMPUTED	0	53	60	30	55	0	0
# OF LINES INVENTORIED	0	31	16	43	30	0	0
# OF LINES TYPED FOR INVENTORY LISTS	0	13	24	227	280	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	0	126	101	0	0	0
# OF ON CALL REQUESTS POSTED	0	0	317	212	0	0	0
# OF RECEIPTS PROCESSED AND FILED	0	0	126	74	0	0	0
# OF PRICE CHANGES PROCESSED	0	0	17	6	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	32	96	100	119	95	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	4	12	12.5	14.875	11.875	4	4

SUMMARY DATA COLLECTION SHEET (19 - 25 NOVEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	35	34	34	34
# OF LINES RECEIVED AND WAREHOUSED	97	118	37	0	84	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	9	28	9	9
# OF EQUIPMENT ITEMS LOANED	1	5	13	1	1	0	1
# OF CARTS CLEANED	5	3	4	75	3	4	8
# OF ON CALLS & DELIVERY REQUESTS	60	58	98	19	24	19	19
# OF ITEMS POSTED TO MASTER SHEET	1518	619	688	0	378	0	0
# OF RECEIPTS POSTED TO RECORDS	74	118	52	0	29	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	691	332	245	0	147	0	0
# OF ITEMS HAVING RO RECOMPUTED	65	70	40	0	29	0	3
# OF LINES INVENTORIED	31	33	39	0	0	0	0
# OF LINES TYPED FOR INVENTORY LISTS	60	15	360	0	90	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	119	44	41	0	0	0	0
# OF ON CALL REQUESTS POSTED	112	60	58	0	0	0	0
# OF RECEIPTS PROCESSED AND FILED	74	167	33	0	0	0	0
# OF PRICE CHANGES PROCESSED	16	21	3	0	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	104	112	101	48	61	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13	14	12.625	6	7.625	4	4

SUMMARY DATA COLLECTION SHEET (26 NOV - 2 DEC 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	28	12	2	137	73	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	3	10	10	7	8	0	4
# OF CARTS CLEANED	3	0	10	76	4	7	3
# OF ON CALLS & DELIVERY REQUESTS	59	72	94	66	72	26	32
# OF ITEMS POSTED TO MASTER SHEET	1393	755	709	836	692	0	0
# OF RECEIPTS POSTED TO RECORDS	71	22	5	107	55	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	435	365	325	377	476	0	0
# OF ITEMS HAVING RO RECOMPUTED	41	28	39	50	44	0	0
# OF LINES INVENTORIED	0	109	2	38	2	0	0
# OF LINES TYPED FOR INVENTORY LISTS	98	30	0	161	270	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	139	44	0	85	41	0	0
# OF ON CALL REQUESTS POSTED	87	59	0	166	66	0	0
# OF RECEIPTS PROCESSED AND FILED	47	28	0	79	33	0	0
# OF PRICE CHANGES PROCESSED	4	1	0	4	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	104	112	100	108	98	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13	14	12.5	13.5	12.25	4	4

SUMMARY DATA COLLECTION SHEET (3 - 9 DECEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	1	2	142	8	105	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	18	10	11	9	11	3	1
# OF CARTS CLEANED	2	3	0	36	2	7	6
# OF ON CALLS & DELIVERY REQUESTS	44	91	75	68	70	35	27
# OF ITEMS POSTED TO MASTER SHEET	1293	673	556	355	814	0	0
# OF RECEIPTS POSTED TO RECORDS	19	29	21	51	88	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	497	298	263	161	327	0	0
# OF ITEMS HAVING RO RECOMPUTED	47	48	16	10	38	0	0
# OF LINES INVENTORIED	0	0	33	0	0	0	0
# OF LINES TYPED FOR INVENTORY LISTS	416	259	61	142	0	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	0	163	44	41	0	0
# OF ON CALL REQUESTS POSTED	0	0	265	75	68	0	0
# OF RECEIPTS PROCESSED AND FILED	0	0	0	251	42	0	0
# OF PRICE CHANGES PROCESSED	0	0	0	37	6	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	104	109	97	101	103	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13	13.625	12.125	12.625	12.875	4	4

SUMMARY DATA COLLECTION SHEET (10 - 16 DECEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	4	82	2	116	36	0	2
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	10	7	16	14	10	2	3
# OF CARTS CLEANED	3	3	0	66	2	6	7
# OF ON CALLS & DELIVERY REQUESTS	68	94	80	88	64	36	60
# OF ITEMS POSTED TO MASTER SHEET	1635	619	745	779	792	0	0
# OF RECEIPTS POSTED TO RECORDS	1	4	59	107	41	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	642	336	366	364	368	0	0
# OF ITEMS HAVING RO RECOMPUTED	46	38	41	48	51	0	0
# OF LINES INVENTORIED	48	30	31	74	70	0	0
# OF LINES TYPED FOR INVENTORY LISTS	127	327	491	113	169	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	78	44	41	44	41	0	0
# OF ON CALL REQUESTS POSTED	122	68	94	80	88	0	0
# OF RECEIPTS PROCESSED AND FILED	75	27	52	0	42	0	0
# OF PRICE CHANGES PROCESSED	21	14	7	0	0	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	116	104	107	109	108	24	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	14.5	13	13.375	13.625	13.5	3	4

SUMMARY DATA COLLECTION SHEET (17 - 23 DECEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	70	71	70	71	70	34	34
# OF LINES RECEIVED AND WAREHOUSED	50	86	15	54	86	0	0
# OF STATIC CARTS REPLENISHED	28	21	28	21	28	9	9
# OF EQUIPMENT ITEMS LOANED	5	13	5	16	7	2	0
# OF CARTS CLEANED	3	3	0	53	4	7	5
# OF ON CALLS & DELIVERY REQUESTS	67	89	50	84	46	16	23
# OF ITEMS POSTED TO MASTER SHEET	1517	827	750	766	637	0	0
# OF RECEIPTS POSTED TO RECORDS	31	12	71	31	91	0	0
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	697	414	493	522	330	0	0
# OF ITEMS HAVING RO RECOMPUTED	37	19	83	37	32	0	0
# OF LINES INVENTORIED	56	60	60	75	78	0	0
# OF LINES TYPED FOR INVENTORY LISTS	138	0	52	60	48	0	0
# OF CART ISSUE SLIPS TOTALED AND POSTED	0	122	41	44	41	0	0
# OF ON CALL REQUESTS POSTED	0	227	89	50	84	0	0
# OF RECEIPTS PROCESSED AND FILED	0	52	36	43	81	0	0
# OF PRICE CHANGES PROCESSED	0	8	0	8	8	0	0
TOTAL NUMBER OF HOURS WORKED IN THE MDS	105	111	104	131	103	32	32
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	13.125	13.875	13	16.375	12.875	4	4

SUMMARY DATA COLLECTION SHEET (24 - 29 DECEMBER 1984)

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
# OF CARTS EXCHANGED	19	0	60	43	59	31	
# OF LINES RECEIVED AND WAREHOUSED	38	0	11	70	59	0	
# OF STATIC CARTS REPLENISHED	28	9	28	21	28	9	
# OF EQUIPMENT ITEMS LOANED	5	0	3	14	4	2	
# OF CARTS CLEANED	5	5	9	37	0	8	
# OF ON CALLS & DELIVERY REQUESTS	37	18	51	40	63	25	
# OF ITEMS POSTED TO MASTER SHEET	1023	0	631	498	426	0	
# OF RECEIPTS POSTED TO RECORDS	46	0	68	31	70	0	
# ITEMS POSTED TO ACCOUNTING RECORDS FROM MASTER SHEET	518	0	258	253	208	0	
# OF ITEMS HAVING RO RECOMPUTED	25	0	47	22	26	0	
# OF LINES INVENTORIED	30	0	60	60	105	0	
# OF LINES TYPED FOR INVENTORY LISTS	63	0	492	60	48	0	
# OF CART ISSUE SLIPS TOTALED AND POSTED	78	0	0	105	41	0	
# OF ON CALL REQUESTS POSTED	85	0	0	105	40	0	
# OF RECEIPTS PROCESSED AND FILED	76	0	0	38	127	0	
# OF PRICE CHANGES PROCESSED	12	0	0	3	10	0	
TOTAL NUMBER OF HOURS WORKED IN THE MDS	65	48	71	91	87	32	
STANDARD WORKDAY EQUIVALENTS (HOURS WORKED/8 HRS IN DAY)	8.125	6	8.875	11.375	10.875	4	

APPENDIX K

MULTIPLE REGRESSION ANALYSIS

USING COLLECTED WORKLOAD DATA

MULTIPLE REGRESSION ANALYSIS USING COLLECTED WORKLOAD DATA

The multiple regression analysis for this study was accomplished with the use of a statistical software package for micro-computers. MICROSTAT, Version 2.0, released by Ecosoft, Inc. was used to perform all statistical analysis.

To perform the multiple regression, data from the daily workload sheets were entered into the computer. Each of the major functions performed by the MDS personnel were identified as the independent variables with the total mandays worked (total hours worked divided by eight hours in a standard work day) as the dependent variable. Once all the data had been entered and verified as being correct, an initial regression analysis was accomplished. The results of this analysis is identified as Step 1 on the attached pages to this appendix.

Based on the initial analysis, a coefficient of determination (R^2) of .9326 was obtained. An R^2 of this magnitude indicates that approximately 93 percent of the variability in the dependent variables is explained or accounted for by the model, or in other words, how well the combination of independent variables predicts the number of hours required to perform the MDS function. This value was considered significant based on the criteria ($R^2 > .8$) established for this project.

To determine the overall significance of this regression equation, a test using the following stated hypotheses was performed:

H_0: All 16 independent variables considered together do not explain a significant amount of the variation in mandays required to perform the MOS functions.

H_A: The independent variables do explain a significant amount of the variation in mandays required to perform the MOS functions.

The overall F statistic for the initial regression was 63.122. This statistic is then compared against the critical point value at the 5 percent level of significance, $F_{16,\ 73,\ \alpha\ =\ .05} = 1.79$. Since the overall F statistic exceeds the critical value, the null hypothesis can be rejected and it can be stated that there is significant overall regression at the 5 percent level of significance.

However, when examining the partial F values to determine whether the best model has been obtained, there are several variables that do not appear to add significantly to the model. At the 5 percent level of significance, the F value at $F_{1,\ 73,\ \alpha\ =\ .05}$ is 3.96. Since there are several partial F values less than this figure, a backward elimination approach was taken to seek the best regression model. Initially, those independent variables with a partial F value of less than .5 (MSTRS, TOTIS, and TOTOC) were dropped and the regression process performed again.

Step 2 revealed a more overall significant regression with the overall F statistic increasing to 80.430. However, there were still several partial F values that were not significant. At the 5 percent level of significance, $F_{1, 75, \alpha = .05} = 3.96$. For this iteration, partial F values less that 1 were dropped from the model. Specifically, the variables LNTYP and PRCHG were removed.

Steps 3 thru 7 continued the iterative process until only significant partial F values were recorded (values greater than 3.96). In the final process, the overall F value was 166.143, the R^2 was .9231, and all of the partial F values were significant.

The final regression model to determine the manpower requirements for the Materiel Distribution Service at Blanchfield Army Community Hospital is as follows:

$$Y = -.8518 + .0942X_1 + .1086X_2 + .0306X_3 + .0270X_4 + .0040X_5 + .0148X_6 \text{ where,}$$

Y = the number of mandays required to operate the MDS
X_1 = the number of carts exchanged on a daily basis
X_2 = the number of static carts replenished to par levels
X_3 = the number of carts cleaned
X_4 = the number of on-call requests received
X_5 = the number of postings to the stock records (DA 3318)
X_6 = the number of lines inventoried

ABBREVIATIONS USED FOR WORKLOAD REGRESSION ANALYSIS

EXCRT: the number of carts exchanged
LNREC: the number of lines received from the central storage facility
STCRT: the number of static carts replenished to par levels
EQLON: the number of items issued from the equipment loan pool
CTCLN: the number of carts cleaned
ONCAL: the number of on-call requests received
MSTRS: the number of lines posted to the master sheet
RECPD: the number of receipt lines posted to accounting records
MTOAC: the number of postings made to the accounting records from the master sheets
ROREC: the number of requisition objectives computed
LNINV: the number of lines inventoried
LNTYP: the number of lines typed for inventory sheets
TOTIS: the number of issues totalled for both exchange and par level carts
TOTOC: the number of on-call requests totalled and posted
RECPS: the number of receipts processed
PRCHG: the number of price changes processed

NOTE: ALL THESE FACTORS ARE BASED ON DAILY WORKLOAD

----- REGRESSION ANALYSIS ----- STEP 1
HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSIOLYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 73)	PARTIAL r^2
EXCRT	0.0819	0.0198	17.098	0.1898
LNREC	0.0067	0.0050	1.764	0.0236
STCRT	0.0681	0.0392	3.023	0.0398
EQLON	0.0797	0.0448	3.172	0.0416
CTCLN	0.0243	0.0088	7.569	0.0939
ONCAL	0.0209	0.0100	4.381	0.0566
MSTRS	-0.0000	0.0009	0.002	0.0000
RECPD	-0.0065	0.0063	1.060	0.0143
MTOAC	0.0039	0.0022	3.109	0.0408
ROREC	0.0110	0.0108	1.050	0.0142
LNINV	0.0127	0.0057	4.980	0.0639
LNTYP	0.0009	0.0013	0.541	0.0074
TOTIS	0.0045	0.0079	0.328	0.0045
TOTOC	-0.0017	0.0051	0.113	0.0015
RECPS	0.0115	0.0068	2.875	0.0379
PRCHG	-0.0307	0.0342	0.807	0.0109
CONSTANT:	-0.0066			

STD. ERROR OF EST. = 1.2630
R SQUARED = 0.9326
MULTIPLE R = 0.9657

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1611.1075	16	100.6942	63.1221
RESIDUAL	116.4517	73	1.5952	
TOTAL	1727.5592	89		

----- REGRESSION ANALYSIS -----STEP 2
HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 76)	PARTIAL r^2
EXCRT	0.0806	0.0192	17.683	0.1888
LNREC	0.0069	0.0044	2.509	0.0320
STCRT	0.0685	0.0373	3.364	0.0424
EQLON	0.0769	0.0423	3.306	0.0417
CTCLN	0.0244	0.0086	7.982	0.0950
ONCAL	0.0220	0.0097	5.205	0.0641
RECPD	-0.0069	0.0059	1.360	0.0176
MTOAC	0.0039	0.0013	9.531	0.1114
ROREC	0.0112	0.0105	1.139	0.0148
LNINV	0.0133	0.0054	6.109	0.0744
LNTYP	0.0008	0.0012	0.471	0.0062
RECPS	0.0123	0.0063	3.801	0.0476
PRCHG	-0.0323	0.0334	0.937	0.0122
CONSTANT:	0.0070			

STD. ERROR OF EST. = 1.2411
R SQUARED = 0.9322
MULTIPLE R = 0.9655

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1610.4988	13	123.8845	80.4305
RESIDUAL	117.0604	76	1.5403	
TOTAL	1727.5592	89		

---- REGRESSION ANALYSIS ----- STEP 3

HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 78)	PARTIAL r^2
EXCRT	0.0837	0.0188	19.857	0.2029
LNREC	0.0064	0.0042	2.269	0.0283
STCRT	0.0745	0.0360	4.291	0.0521
EQLON	0.0798	0.0419	3.618	0.0443
CTCLN	0.0262	0.0083	9.963	0.1133
ONCAL	0.0207	0.0095	4.791	0.0579
RECPD	-0.0061	0.0058	1.100	0.0139
MTOAC	0.0037	0.0012	8.844	0.1018
ROREC	0.0119	0.0104	1.319	0.0166
LNINV	0.0134	0.0053	6.331	0.0751
RECPS	0.0071	0.0031	5.223	0.0628
CONSTANT:	-0.1162			

STD. ERROR OF EST. = 1.2330
R SQUARED = 0.9314
MULTIPLE R = 0.9651

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1608.9782	11	146.2707	96.2137
RESIDUAL	118.5810	78	1.5203	
TOTAL	1727.5592	89		

----- REGRESSION ANALYSIS -----STEP 4

HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 80)	PARTIAL r^2
EXCRT	0.0863	0.0179	23.168	0.2246
LNREC	0.0036	0.0037	0.969	0.0120
STCRT	0.0782	0.0354	4.898	0.0577
EQLON	0.0702	0.0413	2.886	0.0348
CTCLN	0.0265	0.0083	10.296	0.1140
ONCAL	0.0228	0.0092	6.123	0.0711
MTOAC	0.0043	0.0011	14.984	0.1577
LNINV	0.0141	0.0053	7.001	0.0805
RECPS	0.0060	0.0029	4.183	0.0497
CONSTANT:	-0.2860			

STD. ERROR OF EST. = 1.2326
R SQUARED = 0.9296
MULTIPLE R = 0.9642

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1606.0193	9	178.4466	117.4571
RESIDUAL	121.5399	80	1.5192	
TOTAL	1727.5592	89		

----- REGRESSION ANALYSIS -----STEP 5
HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 81)	PARTIAL r^2
EXCRT	0.0870	0.0179	23.597	0.2256
STCRT	0.0831	0.0350	5.643	0.0651
EQLON	0.0666	0.0412	2.616	0.0313
CTCLN	0.0283	0.0080	12.367	0.1325
ONCAL	0.0233	0.0092	6.408	0.0733
MTOAC	0.0044	0.0011	16.202	0.1667
LNINV	0.0146	0.0053	7.592	0.0857
RECPS	0.0060	0.0029	4.259	0.0499
CONSTANT:	-0.3696			

STD. ERROR OF EST. = 1.2323
R SQUARED = 0.9288
MULTIPLE R = 0.9637

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1604.5466	8	200.5683	132.0680
RESIDUAL	123.0126	81	1.5187	
TOTAL	1727.5592	89		

----- REGRESSION ANALYSIS ----- STEP 6

HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 82)	PARTIAL r^2
EXCRT	0.0919	0.0178	26.533	0.2445
STCRT	0.0936	0.0347	7.262	0.0814
CTCLN	0.0303	0.0080	14.277	0.1483
ONCAL	0.0255	0.0092	7.696	0.0858
MTOAC	0.0044	0.0011	15.850	0.1620
LNINV	0.0149	0.0053	7.745	0.0863
RECPS	0.0057	0.0029	3.744	0.0437
CONSTANT:	-0.6111			

STD. ERROR OF EST. = 1.2444
R SQUARED = 0.9265
MULTIPLE R = 0.9625

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1600.5741	7	228.6534	147.6519
RESIDUAL	126.9851	82	1.5486	
TOTAL	1727.5592	89		

----- REGRESSION ANALYSIS -----STEP 7

HEADER DATA FOR: B:SUMDATA LABEL: B:SUMDATA
NUMBER OF CASES: 90 NUMBER OF VARIABLES: 17

WORKLOAD REGRESSION ANALYSIS

INDEX	NAME	MEAN	STD. DEV.
1	EXCRT	56.767	18.641
2	LNREC	36.733	43.915
3	STCRT	20.011	8.143
4	EQLON	5.867	4.570
5	CTCLN	10.644	17.258
6	ONCAL	58.956	26.108
7	MSTRS	588.033	496.198
8	RECPD	31.078	34.281
9	MTOAC	268.289	219.002
10	ROREC	30.233	25.735
11	LNINV	27.756	31.072
12	LNTYP	110.744	153.700
13	TOTIS	35.167	42.215
14	TOTOC	56.133	67.741
15	RECPS	29.911	50.035
16	PRCHG	4.667	9.574
DEP. VAR.:	MNDYS	10.074	4.406

F TO ENTER = 0 , F TO REMOVE = 0 , TOLERANCE = 0.0000

DEPENDENT VARIABLE: MNDYS

VAR.	REGRESSION COEFFICIENT	STD. ERROR	F(1, 83)	PARTIAL r^2
EXCRT	0.0942	0.0181	27.102	0.2462
STCRT	0.1086	0.0344	9.973	0.1073
CTCLN	0.0306	0.0082	14.093	0.1451
ONCAL	0.0270	0.0093	8.454	0.0924
MTOAC	0.0040	0.0011	13.068	0.1360
LNINV	0.0148	0.0054	7.413	0.0820
CONSTANT:	-0.8518			

STD. ERROR OF EST. = 1.2648
R SQUARED = 0.9231
MULTIPLE R = 0.9608

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F RATIO
REGRESSION	1594.7757	6	265.7959	166.1431
RESIDUAL	132.7835	83	1.5998	
TOTAL	1727.5592	89		

TABLE A-4 ***Percentiles of the F distribution (continued)***

Upper 5% point of the F distribution

DEGREES OF FREEDOM FOR DENOMINATOR	DEGREES OF FREEDOM FOR NUMERATOR																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	25	30	40	50	100	150	200
1	161	200	216	225	230	234	237	239	241	242	243	244	245	245	246	246	247	247	248	248	249	250	251	252	253	253	254
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.73	8.71	8.70	8.69	8.68	8.67	8.67	8.66	8.63	8.62	8.59	8.58	8.55	8.54	8.54
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.89	5.87	5.86	5.84	5.83	5.82	5.81	5.80	5.77	5.75	5.72	5.70	5.66	5.65	5.65
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.66	4.64	4.62	4.60	4.59	4.58	4.57	4.56	4.52	4.50	4.46	4.44	4.41	4.39	4.39
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.98	3.96	3.94	3.92	3.91	3.90	3.88	3.87	3.83	3.81	3.77	3.75	3.71	3.70	3.69
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.55	3.53	3.51	3.49	3.48	3.47	3.46	3.44	3.40	3.38	3.34	3.32	3.27	3.26	3.25
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.26	3.24	3.22	3.20	3.19	3.17	3.16	3.15	3.11	3.08	3.04	3.02	2.97	2.96	2.95
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.05	3.03	3.01	2.99	2.97	2.96	2.95	2.94	2.89	2.86	2.83	2.80	2.76	2.74	2.73
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.89	2.86	2.85	2.83	2.81	2.80	2.79	2.77	2.73	2.70	2.66	2.64	2.59	2.57	2.56
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79	2.76	2.74	2.72	2.70	2.69	2.67	2.66	2.65	2.60	2.57	2.53	2.51	2.46	2.44	2.43
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69	2.66	2.64	2.62	2.60	2.58	2.57	2.56	2.54	2.50	2.47	2.43	2.40	2.35	2.33	2.32
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.58	2.55	2.53	2.51	2.50	2.48	2.47	2.46	2.41	2.38	2.34	2.31	2.26	2.24	2.23
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.51	2.48	2.46	2.44	2.43	2.41	2.40	2.39	2.34	2.31	2.27	2.24	2.19	2.17	2.16
15	4.54	3.68	3.29	3.05	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.45	2.42	2.40	2.38	2.37	2.35	2.34	2.33	2.28	2.25	2.20	2.18	2.12	2.10	2.10
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.46	2.42	2.40	2.37	2.35	2.33	2.32	2.30	2.29	2.28	2.23	2.19	2.15	2.12	2.07	2.05	2.04
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.41	2.38	2.35	2.33	2.31	2.29	2.27	2.26	2.24	2.23	2.18	2.15	2.10	2.08	2.02	2.00	1.99
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.31	2.29	2.27	2.25	2.23	2.22	2.20	2.19	2.14	2.11	2.06	2.04	1.98	1.96	1.95
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.34	2.31	2.28	2.26	2.23	2.21	2.20	2.18	2.17	2.16	2.11	2.07	2.03	2.00	1.94	1.92	1.91
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.25	2.22	2.20	2.18	2.17	2.15	2.14	2.12	2.07	2.04	1.99	1.97	1.91	1.89	1.88
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.28	2.25	2.22	2.20	2.18	2.16	2.14	2.12	2.11	2.10	2.05	2.01	1.96	1.94	1.88	1.86	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.26	2.23	2.20	2.17	2.15	2.13	2.11	2.10	2.08	2.07	2.02	1.98	1.94	1.91	1.85	1.83	1.82
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.24	2.20	2.18	2.15	2.13	2.11	2.09	2.08	2.06	2.05	2.00	1.96	1.91	1.88	1.82	1.80	1.79
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18	2.15	2.13	2.11	2.09	2.07	2.05	2.04	2.03	1.97	1.94	1.89	1.86	1.80	1.78	1.77
25	4.24	3.39	2.99	2.75	2.60	2.49	2.40	2.34	2.28	2.24	2.20	2.16	2.14	2.11	2.09	2.07	2.05	2.04	2.02	2.01	1.96	1.92	1.87	1.84	1.78	1.76	1.75
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.18	2.15	2.12	2.09	2.07	2.05	2.03	2.02	2.00	1.99	1.94	1.90	1.85	1.82	1.76	1.74	1.73
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.17	2.13	2.10	2.08	2.06	2.04	2.02	2.00	1.99	1.97	1.92	1.88	1.84	1.81	1.74	1.72	1.71
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.15	2.12	2.09	2.06	2.04	2.02	2.00	1.99	1.97	1.96	1.91	1.87	1.82	1.79	1.73	1.71	1.69
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.14	2.10	2.08	2.05	2.03	2.01	1.99	1.97	1.96	1.94	1.89	1.85	1.81	1.77	1.71	1.69	1.67
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09	2.06	2.04	2.01	1.99	1.98	1.96	1.95	1.93	1.88	1.84	1.79	1.76	1.70	1.67	1.66
32	4.15	3.29	2.90	2.67	2.51	2.40	2.31	2.24	2.19	2.14	2.10	2.07	2.04	2.01	1.99	1.97	1.95	1.94	1.92	1.91	1.85	1.82	1.77	1.74	1.67	1.64	1.63
34	4.13	3.28	2.88	2.65	2.49	2.38	2.29	2.23	2.17	2.12	2.08	2.05	2.02	1.99	1.97	1.95	1.93	1.92	1.90	1.89	1.83	1.80	1.75	1.71	1.65	1.62	1.61
36	4.11	3.26	2.87	2.63	2.48	2.36	2.28	2.21	2.15	2.11	2.07	2.03	2.00	1.98	1.95	1.93	1.92	1.90	1.88	1.87	1.81	1.78	1.73	1.69	1.62	1.60	1.59
38	4.10	3.24	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09	2.05	2.02	1.99	1.96	1.94	1.92	1.90	1.88	1.87	1.85	1.80	1.76	1.71	1.68	1.61	1.58	1.57
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00	1.97	1.95	1.92	1.90	1.89	1.87	1.85	1.84	1.78	1.74	1.69	1.66	1.59	1.56	1.55
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.06	2.03	1.99	1.96	1.94	1.91	1.89	1.87	1.86	1.84	1.83	1.77	1.73	1.68	1.65	1.57	1.55	1.53
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05	2.01	1.98	1.95	1.92	1.90	1.88	1.86	1.84	1.83	1.81	1.76	1.72	1.67	1.63	1.56	1.53	1.52
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.15	2.09	2.04	2.00	1.97	1.94	1.91	1.89	1.87	1.85	1.84	1.82	1.80	1.75	1.71	1.65	1.62	1.55	1.52	1.51
48	4.04	3.19	2.80	2.57	2.41	2.29	2.21	2.14	2.08	2.03	1.99	1.96	1.93	1.90	1.88	1.86	1.84	1.82	1.81	1.79	1.74	1.70	1.64	1.61	1.54	1.51	1.49
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03	1.99	1.95	1.92	1.89	1.87	1.85	1.83	1.81	1.80	1.78	1.73	1.69	1.63	1.60	1.52	1.50	1.48
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.89	1.86	1.84	1.82	1.80	1.78	1.76	1.75	1.69	1.65	1.59	1.56	1.48	1.45	1.44
70	3.98	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.02	1.97	1.93	1.89	1.86	1.84	1.81	1.79	1.77	1.75	1.74	1.72	1.66	1.62	1.57	1.53	1.45	1.42	1.40
80	3.96	3.11	2.72	2.49	2.33	2.21	2.13	2.06	2.00	1.95	1.91	1.88	1.84	1.82	1.79	1.77	1.75	1.73	1.72	1.70	1.64	1.60	1.54	1.51	1.43	1.39	1.38
90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94	1.90	1.86	1.83	1.80	1.78	1.76	1.74	1.72	1.70	1.69	1.63	1.59	1.53	1.49	1.41	1.38	1.36
100	3.94	3.09	2.70	2.45	2.31	2.19	2.10	2.03	1.97	1.93	1.89	1.85	1.82	1.79	1.77	1.75	1.73	1.71	1.69	1.68	1.62	1.57	1.52	1.48	1.39	1.36	1.34
125	3.92	3.07	2.68	2.44	2.29	2.17	2.08	2.01	1.96	1.91	1.87	1.83	1.80	1.77	1.75	1.73	1.71	1.69	1.67	1.66	1.59	1.55	1.49	1.45	1.36	1.33	1.31
150	3.90	3.06	2.66	2.43	2.27	2.16	2.07	2.00	1.94	1.89	1.85	1.82	1.79	1.76	1.73	1.71	1.69	1.67	1.66	1.64	1.58	1.54	1.48	1.44	1.34	1.31	1.29
200	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	1.84	1.80	1.77	1.74	1.72	1.69	1.67	1.66	1.64	1.62	1.56	1.52	1.46	1.41	1.32	1.28	1.26
300	3.87	3.03	2.63	2.40	2.24	2.13	2.04	1.97	1.91	1.86	1.82	1.78	1.75	1.72	1.70	1.68	1.66	1.64	1.62	1.61	1.54	1.50	1.43	1.39	1.30	1.26	1.23
500	3.86	3.01	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85	1.81	1.77	1.74	1.71	1.69	1.66	1.64	1.62	1.61	1.59	1.53	1.48	1.42	1.38	1.28	1.23	1.21
1000	3.85	3.00	2.61	2.38	2.22	2.11	2.02	1.95	1.89	1.84	1.80	1.76	1.73	1.70	1.68	1.65	1.63	1.61	1.60	1.58	1.52	1.47	1.41	1.36	1.26	1.22	1.19

Source: David G. Kleinbaum and Lawrence L. Kupper, Applied Regression Analysis and Other Multivariable Methods, (Boston, MA: Duxbury Press, 1978), Table A-4, p. 499.

APPENDIX L

ANALYSIS OF TIME MEASUREMENT STUDIES

CART EXCHANGE FUNCTION

VARIABLE NAME: MINUTES N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 24.1108

POPULATION STD. DEV. = 6.73476
POPULATION VARIANCE = 45.3569

STD. ERROR OF THE MEAN = .862297

MINIMUM = 10.55
MAXIMUM = 42.2

SUM = 1494.87
SUM OF SQUARES = 38854.6
DEVIATION SS = 2812.13

HEADER DATA FOR: B:CTEXCHG LABEL: CAR EXCHANGE FUNTION
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	25.37	32	21.13
2	27.90	33	19.92
3	32.57	34	23.07
4	28.55	35	33.47
5	28.27	36	31.55
6	29.85	37	19.38
7	37.60	38	23.50
8	31.97	39	22.53
9	26.02	40	19.27
10	42.20	41	15.10
11	22.65	42	15.73
12	22.20	43	19.53
13	22.18	44	20.30
14	27.90	45	17.30
15	21.23	46	17.33
16	15.98	47	19.73
17	38.72	48	23.98
18	39.93	49	13.00
19	25.43	50	23.27
20	23.43	51	15.92
21	15.93	52	19.27
22	29.27	53	31.07
23	16.00	54	30.78
24	27.08	55	21.87
25	22.68	56	24.15
26	29.75	57	20.12
27	25.92	58	32.02
28	23.42	59	17.50
29	28.10	60	15.52
30	29.15	61	16.47
31	23.30	62	10.55

PROCESSING SUPPLY RECEIPTS FUNCTION

VARIABLE NAME: ETIME N = 65
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 65

ARITHMETIC MEAN = 1.67625

SAMPLE STD. DEV. = .657611
SAMPLE VARIANCE = .432452

STD. ERROR OF THE MEAN = .0815666

MINIMUM = .833
MAXIMUM = 3.983

SUM = 108.956
SUM OF SQUARES = 210.314
DEVIATION SS = 27.677

HEADER DATA FOR: B:WHSUPRC LABEL: WHSE SUPPLY RECEIPTS
NUMBER OF CASES: 65 NUMBER OF VARIABLES: 1

OBS #	ETIME	OBS #	MINUTES
1	1.53	34	1.03
2	2.65	35	1.30
3	0.83	36	1.33
4	2.15	37	3.05
5	1.50	38	1.47
6	1.80	39	2.43
7	1.02	40	1.75
8	1.77	41	1.25
9	1.37	42	0.85
10	1.30	43	0.95
11	1.15	44	1.92
12	1.33	45	2.10
13	1.62	46	1.07
14	3.98	47	1.58
15	1.43	48	1.70
16	2.73	49	1.35
17	1.16	50	2.15
18	1.02	51	3.25
19	2.23	52	1.20
20	2.98	53	1.52
21	2.33	54	2.48
22	1.12	55	1.25
23	1.53	56	2.83
24	1.43	57	1.02
25	1.72	58	1.45
26	0.97	59	1.77
27	1.72	60	1.45
28	1.17	61	1.08
29	1.02	62	2.08
30	1.25	63	1.90
31	1.98	64	2.47
32	1.15	65	2.05
33	0.93		

STATIC CART REPLENISHMENT

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 14.5032

SAMPLE STD. DEV. = 4.15744
SAMPLE VARIANCE = 17.2843

STD. ERROR OF THE MEAN = .527996

MINIMUM = 6.98
MAXIMUM = 30

SUM = 899.2
SUM OF SQUARES = 14095.6
DEVIATION SS = 1054.34

HEADER DATA FOR: B:CTSTAT LABEL: STATIC CART REPLENISHMNT
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	16.98	32	13.87
2	13.92	33	11.53
3	10.28	34	19.72
4	8.30	35	15.43
5	14.25	36	13.50
6	15.80	37	14.62
7	13.03	38	19.75
8	12.36	39	13.17
9	16.03	40	17.95
10	9.85	41	10.70
11	14.55	42	10.78
12	12.48	43	10.70
13	11.87	44	10.97
14	7.45	45	13.03
15	12.35	46	14.50
16	11.48	47	30.00
17	21.03	48	12.02
18	18.90	49	11.03
19	17.27	50	6.98
20	23.52	51	10.47
21	11.27	52	12.02
22	17.10	53	13.70
23	11.87	54	14.87
24	13.87	55	11.80
25	13.25	56	14.83
26	17.85	57	14.90
27	11.47	58	24.45
28	22.52	59	14.40
29	19.18	60	14.67
30	16.88	61	14.45
31	13.38	62	18.03

EQUIPMENT LOAN POOL

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 9.75558

SAMPLE STD. DEV. = 3.31435
SAMPLE VARIANCE = 10.9849

STD. ERROR OF THE MEAN = .420923

MINIMUM = 3.333
MAXIMUM = 16.933

SUM = 604.846
SUM OF SQUARES = 6570.7
DEVIATION SS = 670.08

HEADER DATA FOR: B:ELNPL LABEL: EQUIPMENT LOAN POOL
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	7.92	32	9.77
2	8.12	33	8.15
3	5.03	34	10.58
4	3.67	35	5.40
5	7.50	36	6.33
6	9.58	37	5.85
7	4.67	38	13.60
8	6.48	39	8.90
9	8.62	40	14.08
10	13.10	41	11.07
11	10.72	42	7.72
12	8.57	43	11.92
13	11.97	44	12.03
14	14.53	45	13.28
15	8.72	46	10.23
16	16.93	47	12.90
17	15.65	48	8.73
18	16.12	49	8.23
19	12.80	50	7.43
20	9.85	51	6.53
21	15.02	52	6.20
22	10.10	53	3.33
23	11.93	54	5.58
24	8.20	55	7.85
25	11.02	56	5.65
26	9.22	57	14.67
27	6.95	58	10.15
28	11.05	59	13.00
29	10.28	60	16.42
30	10.98	61	7.58
31	8.73	62	6.85

CART CLEANING FUNCTION

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 12.7812

POPULATION STD. DEV. = 3.8993
POPULATION VARIANCE = 15.2045

STD. ERROR OF THE MEAN = .499254

MINIMUM = 6.183
MAXIMUM = 28.5

SUM = 792.437
SUM OF SQUARES = 11071
DEVIATION SS = 942.681

HEADER DATA FOR: B:CTCLNG LABEL: CART CLEANING FUNCTION
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	17.73	32	18.83
2	11.48	33	24.02
3	14.95	34	9.08
4	11.52	35	10.77
5	7.88	36	15.30
6	15.47	37	14.50
7	7.40	38	18.40
8	14.83	39	13.57
9	17.37	40	9.07
10	10.95	41	10.35
11	14.23	42	12.15
12	17.07	43	10.20
13	10.05	44	10.30
14	12.77	45	14.07
15	17.90	46	14.82
16	15.98	47	12.23
17	11.85	48	12.50
18	10.82	49	13.52
19	13.93	50	11.95
20	12.02	51	10.63
21	10.77	52	12.13
22	11.05	53	6.27
23	8.87	54	11.90
24	11.98	55	10.12
25	7.27	56	10.75
26	10.82	57	28.50
27	6.18	58	15.67
28	12.75	59	15.03
29	15.75	60	12.20
30	8.75	61	10.05
31	7.62	62	15.55

DELIVERY SERVICE

VARIABLE NAME: MINUT N = 63
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 63

ARITHMETIC MEAN = 7.38891

SAMPLE STD. DEV. = 2.3935
SAMPLE VARIANCE = 5.72882

STD. ERROR OF THE MEAN = .301552

MINIMUM = 3.65
MAXIMUM = 14.933

SUM = 465.501
SUM OF SQUARES = 3794.73
DEVIATION SS = 355.187

HEADER DATA FOR: B:DELSVC LABEL: DELIVERY SERVICE/CUS AST
NUMBER OF CASES: 63 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	3.72	33	8.10
2	6.92	34	8.42
3	7.93	35	12.27
4	5.70	36	4.12
5	6.85	37	10.07
6	5.75	38	7.35
7	5.82	39	10.87
8	7.15	40	9.52
9	7.62	41	4.80
10	8.93	42	7.13
11	6.25	43	3.77
12	8.18	44	7.12
13	9.75	45	7.75
14	4.58	46	7.83
15	10.47	47	8.87
16	4.32	48	5.85
17	7.47	49	6.02
18	6.72	50	4.68
19	8.38	51	5.25
20	6.15	52	3.65
21	14.93	53	7.73
22	10.03	54	8.47
23	4.62	55	9.12
24	7.45	56	8.80
25	4.27	57	8.57
26	4.33	58	8.13
27	4.78	59	11.65
28	4.98	60	11.25
29	5.18	61	10.58
30	4.93	62	7.83
31	6.12	63	10.63
32	9.03		

LABEL: POSTING FM CART ISSUE SLIP TO MSTR SHEET

VARIABLE NAME: MINUT N = 64
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 64

ARITHMETIC MEAN = 1.16636

SAMPLE STD. DEV. = .659948
SAMPLE VARIANCE = .435532

STD. ERROR OF THE MEAN = .0824935

MINIMUM = .317
MAXIMUM = 4

SUM = 74.647
SUM OF SQUARES = 114.504
DEVIATION SS = 27.4385

HEADER DATA FOR: B:ITOMSR LABEL: ISSUES TO MASTER LIST
NUMBER OF CASES: 64 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.80	33	1.82
2	0.58	34	0.87
3	1.75	35	0.62
4	0.38	36	0.52
5	1.13	37	0.52
6	0.83	38	0.92
7	0.83	39	2.05
8	0.92	40	0.63
9	0.83	41	0.97
10	0.53	42	0.92
11	1.35	43	0.73
12	1.33	44	0.35
13	0.98	45	1.28
14	0.82	46	1.55
15	2.72	47	0.32
16	0.70	48	4.00
17	1.83	49	1.33
18	1.62	50	1.08
19	2.12	51	2.13
20	1.10	52	0.90
21	1.97	53	0.97
22	0.83	54	0.93
23	0.60	55	0.65
24	0.40	56	1.93
25	0.45	57	1.75
26	0.58	58	2.10
27	1.88	59	1.50
28	1.25	60	1.78
29	1.78	61	0.83
30	1.55	62	0.83
31	1.28	63	0.55
32	0.77	64	0.80

POSTING RECEIPTS TO MATERIEL RECORDS

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = .740323

SAMPLE STD. DEV. = .208308
SAMPLE VARIANCE = .0433923

STD. ERROR OF THE MEAN = .0264552

MINIMUM = .367
MAXIMUM = 1.283

SUM = 45.9
SUM OF SQUARES = 36.6277
DEVIATION SS = 2.64693

HEADER DATA FOR: B:POSTREC LABEL: POSTING MATERIEL RECPTS
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.95	32	0.55
2	0.87	33	0.48
3	1.28	34	0.57
4	0.80	35	0.63
5	0.90	36	0.48
6	0.88	37	0.47
7	1.08	38	0.58
8	1.03	39	0.65
9	0.87	40	0.62
10	1.15	41	0.67
11	1.22	42	0.58
12	0.82	43	0.85
13	0.92	44	0.77
14	1.23	45	0.95
15	0.73	46	0.88
16	0.75	47	0.80
17	0.62	48	0.97
18	0.65	49	0.88
19	0.92	50	0.67
20	0.57	51	0.60
21	0.58	52	0.70
22	0.58	53	0.72
23	0.57	54	0.73
24	0.37	55	0.62
25	0.73	56	0.48
26	0.55	57	0.70
27	0.58	58	0.57
28	0.45	59	0.60
29	0.83	60	0.62
30	0.55	61	0.90
31	0.53	62	1.05

LABEL: POST MASTER RECORD TO ACCOUNTING SHEETS

VARIABLE NAME: MINUT N = 65
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 65

ARITHMETIC MEAN = .388862

SAMPLE STD. DEV. = .139745
SAMPLE VARIANCE = .0195286

STD. ERROR OF THE MEAN = .0173332

MINIMUM = .183
MAXIMUM = .817

SUM = 25.276
SUM OF SQUARES = 11.0787
DEVIATION SS = 1.24983

NUMBER OF CASES: 65 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.53	34	0.28
2	0.68	35	0.32
3	0.50	36	0.30
4	0.47	37	0.27
5	0.47	38	0.23
6	0.55	39	0.23
7	0.45	40	0.28
8	0.47	41	0.42
9	0.42	42	0.42
10	0.53	43	0.35
11	0.52	44	0.37
12	0.53	45	0.42
13	0.47	46	0.30
14	0.42	47	0.28
15	0.22	48	0.30
16	0.73	49	0.40
17	0.55	50	0.43
18	0.47	51	0.22
19	0.25	52	0.52
20	0.28	53	0.55
21	0.27	54	0.35
22	0.28	55	0.45
23	0.43	56	0.43
24	0.23	57	0.82
25	0.20	58	0.45
26	0.22	59	0.48
27	0.22	60	0.67
28	0.23	61	0.48
29	0.28	62	0.33
30	0.18	63	0.45
31	0.23	64	0.40
32	0.18	65	0.28
33	0.33		

LABEL: RE-COMPUTING STOCK LVLS & REORDERING

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 2.3821

SAMPLE STD. DEV. = .605505
SAMPLE VARIANCE = .366637

STD. ERROR OF THE MEAN = .0768992

MINIMUM = 1.73
MAXIMUM = 4.78

SUM = 147.69
SUM OF SQUARES = 374.177
DEVIATION SS = 22.3648

HEADER DATA FOR: B:STKRECP LABEL: STOCKAGE RECOMPUTATION
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	3.33	32	2.33
2	2.22	33	2.00
3	1.97	34	2.82
4	2.07	35	2.38
5	1.73	36	2.18
6	1.73	37	2.13
7	1.87	38	2.00
8	1.93	39	2.15
9	2.73	40	2.25
10	2.28	41	2.15
11	2.37	42	1.97
12	2.38	43	1.98
13	2.62	44	2.27
14	2.17	45	2.58
15	1.77	46	2.60
16	2.18	47	2.28
17	3.75	48	2.48
18	1.90	49	2.07
19	2.18	50	4.33
20	1.85	51	2.25
21	2.13	52	2.38
22	1.77	53	2.40
23	2.02	54	2.58
24	2.03	55	2.87
25	2.02	56	3.98
26	2.07	57	2.72
27	4.78	58	2.00
28	1.92	59	2.82
29	2.23	60	3.53
30	2.33	61	2.58
31	2.30	62	2.00

LABEL: WAREHOUSE INVENTORY

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 1.34589

SAMPLE STD. DEV. = .531172
SAMPLE VARIANCE = .282143

STD. ERROR OF THE MEAN = .0674589

MINIMUM = .367
MAXIMUM = 3.15

SUM = 83.445
SUM OF SQUARES = 129.518
DEVIATION SS = 17.2107

HEADER DATA FOR: B:WHSEINV LABEL: WAREHOUSE INVENTORY
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUT	OBS #	MINUTES
1	0.97	32	0.97
2	1.20	33	0.77
3	3.15	34	0.87
4	1.52	35	1.83
5	1.52	36	0.73
6	2.68	37	1.57
7	1.55	38	1.27
8	1.28	39	0.83
9	2.00	40	1.55
10	1.48	41	1.17
11	2.78	42	0.48
12	1.18	43	1.05
13	1.40	44	1.12
14	1.03	45	1.22
15	0.73	46	1.40
16	2.00	47	1.78
17	1.58	48	0.92
18	1.02	49	1.32
19	1.63	50	1.27
20	1.72	51	1.47
21	2.28	52	1.27
22	1.00	53	1.38
23	1.62	54	0.83
24	1.80	55	0.37
25	1.87	56	0.65
26	0.50	57	1.28
27	1.03	58	1.33
28	1.97	59	1.13
29	1.62	60	1.23
30	1.07	61	0.77
31	1.32	62	1.13

LABEL: PREPARE CART LISTINGS

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = .524839

SAMPLE STD. DEV. = .174767
SAMPLE VARIANCE = .0305434

STD. ERROR OF THE MEAN = .0221954

MINIMUM = .3
MAXIMUM = 1.02

SUM = 32.54
SUM OF SQUARES = 18.9414
DEVIATION SS = 1.86315

HEADER DATA FOR: B:CTLIST LABEL: PREPARE CART LISTINGS
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.37	32	0.82
2	0.40	33	0.52
3	0.30	34	0.43
4	0.70	35	0.47
5	0.63	36	0.33
6	0.43	37	0.43
7	0.38	38	0.32
8	0.83	39	0.43
9	0.77	40	0.80
10	0.43	41	0.60
11	0.97	42	0.57
12	0.47	43	0.43
13	0.52	44	0.40
14	0.45	45	0.47
15	0.52	46	0.67
16	0.55	47	0.48
17	0.43	48	0.43
18	0.52	49	0.55
19	0.47	50	0.47
20	0.38	51	0.48
21	0.75	52	0.40
22	0.37	53	0.42
23	0.37	54	0.37
24	0.38	55	0.85
25	0.37	56	0.45
26	0.43	57	0.48
27	0.55	58	0.63
28	0.72	59	0.47
29	0.73	60	0.35
30	1.00	61	0.33
31	1.02	62	0.48

LABEL: RECORD DOLLAR VALUE OF CART ISSUES

VARIABLE NAME: TIME N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 1.22226

SAMPLE STD. DEV. = .447028
SAMPLE VARIANCE = .199834

STD. ERROR OF THE MEAN = .0567726

MINIMUM = .58
MAXIMUM = 2.78

SUM = 75.78
SUM OF SQUARES = 104.813
DEVIATION SS = 12.1899

HEADER DATA FOR: B:RECCTIS LABEL: RECORD CART ISSUES
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	TIME	OBS #	MINUTES
1	0.78	32	1.03
2	0.73	33	1.88
3	0.88	34	2.13
4	0.77	35	0.98
5	1.37	36	0.92
6	1.32	37	1.23
7	1.63	38	1.15
8	0.92	39	1.82
9	1.12	40	1.88
10	1.57	41	0.93
11	0.72	42	1.07
12	0.58	43	0.83
13	1.12	44	1.63
14	0.77	45	1.85
15	1.10	46	1.07
16	0.62	47	1.52
17	1.05	48	1.05
18	0.65	49	1.72
19	0.90	50	2.03
20	1.22	51	1.50
21	0.72	52	1.77
22	0.77	53	1.50
23	0.73	54	1.00
24	1.03	55	1.30
25	0.75	56	1.03
26	0.60	57	1.62
27	2.78	58	1.67
28	1.45	59	1.27
29	1.12	60	1.35
30	1.05	61	1.15
31	1.85	62	1.23

LABEL: POST ON CALL CUSTOMER RECORDS TO FINANCIAL RECORDS

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 1.00837

SAMPLE STD. DEV. = .211295
SAMPLE VARIANCE = .0446454

STD. ERROR OF THE MEAN = .0268345

MINIMUM = .7
MAXIMUM = 1.6

SUM = 62.519
SUM OF SQUARES = 65.7657
DEVIATION SS = 2.72337

HEADER DATA FOR: B:ONCOL LABEL: POST ON CALL REQUESTS
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.88	32	1.08
2	0.82	33	1.07
3	0.97	34	0.87
4	0.95	35	1.60
5	1.10	36	0.97
6	0.97	37	0.88
7	0.78	38	0.77
8	0.92	39	1.13
9	0.87	40	1.35
10	1.12	41	1.35
11	0.90	42	1.00
12	0.75	43	1.05
13	0.93	44	1.38
14	1.20	45	0.70
15	1.28	46	1.17
16	1.08	47	1.40
17	1.05	48	0.87
18	1.05	49	0.95
19	1.25	50	1.17
20	1.00	51	1.07
21	0.72	52	0.85
22	0.88	53	0.90
23	1.10	54	0.88
24	0.82	55	1.15
25	1.02	56	0.82
26	1.45	57	0.70
27	1.57	58	0.73
28	0.75	59	0.93
29	0.85	60	0.95
30	0.77	61	1.12
31	0.85	62	1.03

LABEL: COMPUTE AND UPDATE UNIT OF MEASURE PRICE

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = 1.34086

SAMPLE STD. DEV. = .338914
SAMPLE VARIANCE = .114863

STD. ERROR OF THE MEAN = .0430422

MINIMUM = .5
MAXIMUM = 2.167

SUM = 83.133
SUM OF SQUARES = 118.476
DEVIATION SS = 7.00664

HEADER DATA FOR: B:UPDUM LABEL: UPDATE UNIT OF MEASURE
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	1.97	32	1.95
2	2.17	33	1.52
3	1.90	34	1.17
4	1.57	35	1.28
5	1.45	36	1.43
6	1.80	37	1.08
7	1.75	38	1.12
8	2.05	39	1.28
9	1.38	40	1.23
10	2.07	41	1.42
11	1.35	42	1.22
12	0.98	43	1.50
13	1.58	44	1.12
14	1.78	45	1.73
15	1.60	46	1.17
16	1.52	47	1.33
17	1.32	48	1.10
18	1.22	49	1.18
19	1.27	50	1.00
20	0.73	51	1.18
21	1.57	52	1.28
22	0.93	53	1.62
23	0.93	54	0.83
24	1.32	55	1.05
25	1.48	56	1.35
26	0.87	57	1.18
27	0.97	58	1.38
28	1.20	59	0.93
29	1.40	60	0.50
30	1.27	61	1.10
31	1.25	62	1.25

LABEL: PROCESS AND FILE RECEIPT DOCUMENTS

VARIABLE NAME: MINUT N = 62
BEGINNING CASE NO. = 1 , ENDING CASE NO. = 62

ARITHMETIC MEAN = .656742

SAMPLE STD. DEV. = .157582
SAMPLE VARIANCE = .0248322

STD. ERROR OF THE MEAN = .020013

MINIMUM = .367
MAXIMUM = 1.15

SUM = 40.718
SUM OF SQUARES = 28.256
DEVIATION SS = 1.51477

HEADER DATA FOR: B:FLREC LABEL: PROC & FILE REC DOCUMENT
NUMBER OF CASES: 62 NUMBER OF VARIABLES: 1

OBS #	MINUTES	OBS #	MINUTES
1	0.52	32	0.42
2	0.57	33	0.72
3	0.65	34	0.65
4	0.48	35	0.47
5	0.43	36	0.85
6	0.67	37	0.75
7	0.77	38	0.67
8	0.37	39	0.72
9	0.60	40	0.52
10	0.65	41	0.53
11	0.73	42	0.68
12	0.87	43	0.77
13	0.72	44	0.88
14	0.60	45	0.43
15	0.83	46	0.70
16	0.57	47	0.75
17	1.05	48	0.73
18	0.88	49	0.68
19	0.97	50	0.52
20	1.15	51	0.55
21	0.48	52	0.83
22	0.55	53	0.70
23	0.68	54	0.55
24	0.80	55	0.70
25	0.67	56	0.40
26	0.73	57	0.52
27	0.62	58	0.57
28	0.50	59	0.63
29	0.45	60	0.60
30	0.67	61	0.67
31	0.53	62	0.82

APPENDIX M

CONVERSION OF MEAN TIME TO PERFORM MDS TASKS TO STANDARD FRACTIONAL MANDAY EQUIVALENTS

CALCULATION OF COEFFICIENTS FOR THE DERIVED EQUATION

DESCRIPTION OF MDS FUNCTIONS FOR WHICH TIME ANALYSIS WAS PERFORMED	MEAN TIME TO PERFORM THE TASK (IN MINUTES)	MEAN TIME CONVERTED TO FRACTIONAL MANDAYS (EQUATION COEFFICIENTS)*
WAREHOUSE FUNCTIONS		
1. EXCHANGE CART REPLENISHMENT	24.1108	0.0578
2. RECEIPT OF SUPPLIES	1.6763	0.0040
3. STATIC CART REPLENISHMENT	14.5032	0.0347
4. EQUIPMENT LOAN POOL	9.7556	0.0234
5. CART CLEANING	12.7812	0.0306
6. ON-CALL DELIVERY SERVICE	7.3889	0.0177
STOCK ACCOUNTING FUNCTIONS		
7. POSTING CART ISSUES TO THE MASTER SHEET	1.1664	0.0028
8. POSTING RECEIPTS TO RECORDS (DA FORM 3318)	0.7403	0.0018
9. POSTING FROM MASTER SHEET TO THE RECORDS (DA FORM 3318)	0.3888	0.0009
10. RECOMPUTATION OF STOCKAGE LEVELS & REORDERING	2.3821	0.0057
11. INVENTORY OF STOCKED ITEMS	1.3459	0.0032
12. TYPE A LINE FOR AN INVENTORY LIST OR A CART STOCKAGE LIST	0.5248	0.0013
COST ACCOUNTING FUNCTION		
13. TOTAL & POST CART ISSUE SLIPS	1.2223	0.0029
14. TOTAL & POST ON CALL REQUESTS	1.0084	0.0024
15. PROCESS & FILE RECEIPT DOCS	0.6567	0.0016
16. PROCESS PRICE CHANGE	1.3409	0.0032

* OBTAINED BY DIVIDING THE MEAN TIME TO PERFORM THE TASK BY MEAN NUMBER OF PRODUCTIVE MINUTES AVAILABLE PER MANDAY (417.5 MINUTES)

APPENDIX N

PAIRED COMPARISON HYPOTHESIS TEST

COMPARING TWO EQUATIONS TO DETERMINE THE NUMBER OF MANDAYS NECESSARY TO OPERATE THE MDS BASED ON HISTORICAL DATA FOR A NINETY DAY PERIOD

OBSERVATION NUMBER	MANDAYS ENGINEERED EQUATION	REGRESSION EQUATION	DIFFERENCE (REG-ENG)	D*D
1	11.22	13.33	2.11	4.45
2	10.67	13.36	2.69	7.22
3	10.58	13.36	2.78	7.70
4	12.51	14.47	1.97	3.87
5	12.16	14.23	2.07	4.30
6	3.08	4.43	1.36	1.85
7	3.02	4.25	1.22	1.50
8	3.34	4.25	0.91	0.83
9	12.39	13.27	0.88	0.77
10	10.72	12.49	1.77	3.13
11	12.57	13.98	1.41	1.99
12	9.88	13.15	3.27	10.69
13	3.12	4.41	1.29	1.67
14	3.38	4.76	1.38	1.90
15	12.21	13.82	1.62	2.61
16	11.00	13.42	2.42	5.86
17	11.43	14.07	2.64	6.95
18	9.94	12.51	2.58	6.63
19	9.89	13.59	3.70	13.66
20	2.95	4.25	1.29	1.67
21	2.86	4.15	1.29	1.66
22	11.05	12.79	1.74	3.03
23	10.35	12.96	2.62	6.84
24	11.15	13.66	2.52	6.33
25	11.42	14.22	2.80	7.83
26	9.02	12.36	3.34	11.12
27	2.89	4.15	1.26	1.59
28	3.09	4.48	1.40	1.95
29	13.19	14.36	1.17	1.37
30	10.77	12.16	1.40	1.95
31	10.70	14.45	3.75	14.07
32	10.22	12.38	2.16	4.68
33	10.28	12.86	2.58	6.67
34	3.24	4.47	1.23	1.51
35	3.11	4.32	1.21	1.46
36	14.01	14.76	0.75	0.57
37	10.27	11.67	1.40	1.96
38	9.63	13.07	3.44	11.83
39	11.95	12.98	1.03	1.06

MANDAYS

OBSERVATION NUMBER	ENGINEERED EQUATION	REGRESSION EQUATION	DIFFERENCE (REG-ENG)	D*D
40	11.09	13.66	2.57	6.58
41	3.08	4.46	1.38	1.90
42	3.29	4.78	1.48	2.20
43	2.89	4.18	1.29	1.66
44	13.54	13.41	-0.14	0.02
45	10.57	12.39	1.82	3.32
46	11.49	12.34	0.85	0.72
47	9.61	12.70	3.09	9.55
48	3.03	4.38	1.35	1.82
49	2.87	4.08	1.21	1.47
50	12.98	13.79	0.81	0.65
51	9.91	11.60	1.68	2.82
52	10.71	13.11	2.40	5.78
53	4.99	6.23	1.24	1.54
54	5.34	6.72	1.38	1.92
55	2.74	3.96	1.23	1.51
56	2.88	4.09	1.21	1.45
57	11.82	12.21	0.40	0.16
58	9.74	13.14	3.40	11.56
59	9.99	13.21	3.22	10.35
60	13.31	14.30	0.99	0.98
61	10.30	12.79	2.49	6.21
62	2.95	4.25	1.29	1.67
63	3.03	4.29	1.26	1.58
64	11.19	12.03	0.83	0.69
65	9.59	11.86	2.27	5.16
66	10.39	12.35	1.97	3.86
67	9.68	11.70	2.02	4.09
68	10.31	12.05	1.73	3.01
69	3.18	4.49	1.31	1.71
70	2.96	4.24	1.28	1.64
71	13.01	14.00	0.99	0.98
72	10.24	12.54	2.30	5.29
73	10.79	12.87	2.08	4.34
74	12.88	15.07	2.19	4.79
75	10.34	13.08	2.74	7.50
76	3.15	4.49	1.34	1.80
77	3.63	5.16	1.53	2.35
78	12.11	14.30	2.19	4.79
79	11.17	13.16	1.99	3.98
80	9.87	12.98	3.10	9.63
81	12.07	15.21	3.14	9.84
82	9.68	12.62	2.95	8.69
83	2.82	3.69	0.87	0.76
84	2.84	3.82	0.98	0.97
85	7.47	7.65	0.18	0.03
86	0.78	0.77	-0.02	0.00
87	8.59	11.42	2.82	7.97
88	8.36	9.59	1.23	1.52
89	8.33	11.83	3.50	12.28
90	2.84	3.97	1.13	1.27
	COLUMN TOTALS		162.96	363.06

HYPOTHESIS TEST TO DETERMINE IF A DIFFERENCE EXISTS BETWEEN THE POPULATION MEAN MANDAYS CALCULATED BY THE TWO MODELS DEVELOPED FOR STAFFING THE MDS

HYPOTHESIS:

$H_o : \mu_d \geq 0$

$H_a : \mu_d < 0$

TEST STATISTIC:

$$t = \frac{\bar{d} - \mu_d}{s_{\bar{d}}}, \text{ where } s_{\bar{d}} = s_d / \sqrt{n}$$

$$\bar{d} = \frac{\sum d_i}{n} = \frac{16.296}{90} = 1.81$$

$$s_d^2 = \frac{n \sum d_i^2 - (\sum d)^2}{n(n-1)} = \frac{90(363.06) - (162.96)^2}{90(89)} = .764$$

therefore,

$$t = \frac{1.81 - 0}{\sqrt{.764/90}} = 19.64$$

The critical value of t at α =.05 is $\pm$ 1.9867.

CONCLUSION:

Since the test statistic (19.64) is greater than the critical value, the null hypothesis is rejected and it may be concluded that there is a difference between the population mean mandays of the two equations.

APPENDIX O

COMPARISON OF THE TWO MODELS:

NUMBER OF FULL TIME EQUIVALENTS

REQUIRED TO STAFF THE MDS

MANDAY CALCULATIONS FOR MDS USING BOTH PREDICTIVE MODELS

DATE	ACTUAL MNHRS WORKED	MANDAYS REQUIRED BASED ON ENGINEERED MODEL (ENG)	MANDAYS REQUIRED BASED ON REGRESSION MODEL (MR)	DIFFERENCE MR-ENG
OCT 1	110.00	11.220	13.333	2.11
2	118.00	10.674	13.360	2.69
3	111.00	10.581	13.356	2.78
4	121.00	12.506	14.474	1.97
5	112.00	12.155	14.229	2.07
6	32.00	3.076	4.434	1.36
7	32.00	3.022	4.245	1.22
8	40.00	3.340	4.251	0.91
9	103.00	12.390	13.266	0.88
10	103.00	10.724	12.492	1.77
11	112.00	12.567	13.978	1.41
12	110.00	9.878	13.148	3.27
13	32.00	3.118	4.411	1.29
14	32.00	3.382	4.759	1.38
15	88.00	12.206	13.822	1.62
16	104.00	11.000	13.421	2.42
17	112.00	11.428	14.066	2.64
18	127.00	9.936	12.511	2.58
19	92.00	9.944	13.587	3.64
20	24.00	2.952	4.245	1.29
21	32.00	2.858	4.146	1.29
22	96.00	11.052	12.792	1.74
23	111.00	10.347	12.962	2.62
24	102.00	11.147	13.662	2.52
25	127.00	11.418	14.216	2.80
26	101.00	9.020	12.355	3.33
27	24.00	2.885	4.146	1.26
28	32.00	3.085	4.481	1.40
29	113.00	13.187	14.355	1.17
30	108.00	10.766	12.162	1.40
31	111.00	10.699	12.450	1.75
NOV 1	118.00	10.217	12.380	2.16
2	101.00	10.283	12.862	2.58
3	28.00	3.238	4.469	1.23
4	32.00	3.109	4.315	1.21
5	107.00	14.006	14.759	0.75
6	104.00	10.267	11.688	1.42
7	90.00	9.634	13.073	3.44
8	96.00	11.951	12.982	1.03
9	93.00	11.090	13.656	2.57
10	24.00	3.081	4.458	1.38
11	32.00	3.291	4.775	1.48
12	32.00	2.888	4.177	1.29
13	96.00	13.542	13.407	-0.14
14	100.00	10.570	12.391	1.82

MANDAY CALCULATIONS FOR MDS USING BOTH PREDICTIVE MODELS

DATE	ACTUAL MNHRS WORKED	MANDAYS REQUIRED BASED ON ENGINEERED MODEL (ENG)	MANDAYS REQUIRED BASED ON REGRESSION MODEL (MR)	DIFFERENCE MR-ENG
NOV15	119.00	11.494	12.341	0.85
16	95.00	9.609	12.700	3.09
17	32.00	3.028	4.377	1.35
18	32.00	2.869	4.083	1.21
19	104.00	12.981	13.786	0.81
20	112.00	9.914	11.595	1.68
21	101.00	10.709	13.112	2.40
22	48.00	4.990	6.232	1.24
23	61.00	5.338	6.722	1.38
24	32.00	2.736	3.964	1.23
25	32.00	2.882	4.087	1.21
26	104.00	11.817	12.214	0.40
27	112.00	9.736	13.136	3.40
28	100.00	9.990	13.207	3.22
29	108.00	13.311	14.300	0.99
30	98.00	10.297	12.789	2.49
DEC 1	32.00	2.952	4.245	1.29
2	32.00	3.029	4.285	1.26
3	104.00	11.193	12.026	0.83
4	109.00	9.592	11.863	2.27
5	97.00	10.387	12.352	1.97
6	101.00	9.680	11.702	2.02
7	103.00	10.312	12.047	1.74
8	32.00	3.181	4.488	1.31
9	32.00	2.962	4.242	1.28
10	116.00	13.008	13.996	0.99
11	104.00	10.239	12.539	2.30
12	107.00	10.786	12.870	2.08
13	109.00	12.880	15.068	2.19
14	108.00	10.344	13.083	2.74
15	24.00	3.145	4.485	1.34
16	32.00	3.632	5.164	1.53
17	105.00	12.113	14.308	2.20
18	111.00	11.165	13.160	2.00
19	104.00	9.874	12.997	3.12
20	131.00	12.073	15.210	3.14
21	103.00	9.677	12.624	2.95
22	32.00	2.822	3.692	0.87
23	32.00	2.838	3.820	0.98
24	65.00	7.471	7.653	0.18
25	48.00	0.784	0.765	-0.02
26	71.00	8.593	11.416	2.82
27	91.00	8.362	9.594	1.23
28	87.00	8.329	11.834	3.51
29	32.00	2.838	3.966	1.13
COLUMN TOTALS:		745.688	906.646	160.96

CALCULATION AND COMPARISON OF FULL TIME EQUIVALENTS USING THE TWO MODELS BASED ON MONTHLY WORKLOAD

MONTH	# WORKDAYS	TOTAL # MANDAYS PER MONTH	
		MULT REG MODEL	ENG MODEL
OCT	22.00	333.57	272.56
NOV	20.00	298.04	248.87
DEC	20.00	275.49	224.26

FTE MANPOWER REQUIREMENTS
BY MONTH:

MONTH	TOTAL # FTEs PER MONTH		DIFFERENCE	%
	MULT REG MODEL	ENG MODEL	(MR - ENG)	DIFFERENCE
OCT	15.16	12.39	2.77	22.38
NOV	14.90	12.44	2.46	19.76
DEC	13.77	11.21	2.56	22.85

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